URINARY DEPOSITS,

THEIR

DIAGNOSIS, PATHOLOGY,

ETC.

URINARY DEPOSITS,

THEIR

DIAGNOSIS, PATHOLOGY,

AND

THERAPEUTICAL INDICATIONS.

BY

GOLDING BIRD, M.D. F.R.S.

Fifth Edition.

EDITED BY

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MEDICINA LITERIS

LONDON:
JOHN CHURCHILL, NEW BURLINGTON STREET.
MDCCCLVII.

Was ich ergreife, das ist heut
Fürwahr nur skizzenweise.

PRINTED BY J. E. ADLARD, BARTHOLOMEW CLOSE.

TO

GEORGE HILARO BARLOW,

M.A. M.D. TRIN. COLL. CANTAB., PHYSICIAN TO GUY'S HOSPITAL,

WHOSE LABOURS HAVE AIDED THE ADVANCEMENT OF RATIONAL MEDICINE,

IN REMEMBRANCE OF

KINDNESS RECEIVED AND KNOWLEDGE COMMUNICATED,

This Edition,

A PLEDGE OF FRIENDSHIP AND TRIBUTE OF RESPECT,

IS GRATEFULLY INSCRIBED,

BY HIS FAITHFUL AND ATTACHED FRIEND,

THE EDITOR.

PREFACE.

TO THE

FIFTH EDITION.

I HAVE deeply felt the responsibility of undertaking the charge of a new edition of this the most important work of the late Dr. Golding Bird. His extensive knowledge, his skill in handling his materials, and his lucid narrative, have greatly increased my difficulty. These I cannot emulate, but to fulfil my trust both to the profession and the memory of my friend, I have earnestly laboured. My first thought and object has been to bring the work fully up to the present period, and at the same time, as far as possible, to preserve throughout his delicate touch. In doing this, the new matter has in some places been woven into the text, and in others thrown into notes. In a literary point of view it might have been more correct to have reduced the whole to a simple narrative, but from feelings of respect, I have hesitated to remove some passages and plates, although they may have lost a portion of their value from the recent progress of scientific inquiry.

In preparing this edition, I have made free use of the

work of those who have laboured in the different parts of the same field, and it is a pleasure in this place to record my obligations to Dr. Andrew Clark, for his valuable counsel; Dr. Day, for his 'Contributions to Urology'* as well as for his excellent and most useful translation of Lehmann's 'Physiological Chemistry;' also to Dr. Hassall, the able reviewer of the previous edition, to Dr. Letheby, Dr. Johnson, Dr. Pavy, and others. I have mentioned the names of these physicians in the body of the work, in connection with their respective subjects, but here also I feel called upon to acknowledge my debt to them, and my high estimation of the usefulness of their labours.

Dr. Garrod's lectures before the College of Physicians have been printed since my remarks on diabetes were prepared; but, on consideration, I see no reason to alter or qualify what I have written on the subject.

The use of the microscope is now so generally taught in the schools, that any attempt to urge its claims to attention might be out of place. But I say emphatically to our students: "Do not neglect your opportunities; in the hurry and labour of general practice, you will have little leisure to give to the study of the instrument, and without it you can but imperfectly fulfil your duty, either to yourselves or your patients." Instances are numerous, where without its aid much knowledge would be missed, or great errors committed. I may, however, mention one instance of late occurrence. A gentleman

* 'British and Foreign Medico-Chirurgical Review.'

came to me one morning in a state of great excitement; he stated that on being called at night to micturate, it was some time before the urine began to flow, and that only after straining and the apparent removal of some obstruction. On looking into the vessel in the morning, he found a small reddish mass imbedded in the urates at the bottom; he secured and brought it to me. I put it under the microscope, and found at once that it consisted of fibre of voluntary muscle, and concluded that it had most probably been dislodged from between the teeth, and had been spit into the vessel. The gentlemen left me disburdened of the idea of hæmaturia and calculus.

Dr. Lionel Beale's work on the microscope is, I believe, the best on the subject, and M. Pillischer, of New Bond Street, has manufactured an instrument which he calls his student's microscope; and in justice to him it ought to be known that he first brought within the students' means a good instrument at a reasonable cost.

In conclusion, a word is due to the memory of the author. His time and his strength, both of body and mind, were given to the profession, and he reaped, as a natural consequence, its highest rewards; but those who knew him best, felt that he had brighter hopes beyond, which supported him through a life of sickness, and comforted him at its close.

48, Russell Square,
August, 1857.

TO

DR. ADDISON,

SENIOR PHYSICIAN TO GUY'S HOSPITAL, ETC.

October 24th, 1844.

My dear Sir,

It is now thirteen years ago since I first found myself within the walls of Guy's Hospital, a stranger and unknown. In a short time, my admiration and respect were excited by your profound knowledge and experience as a physician, and for your zeal as a teacher. But I soon experienced another feeling, that of gratitude, for numerous acts of the most disinterested friendship; and for which I must ever remain your debtor.

I cannot look back upon my past career, so far as it has extended, without gratefully acknowledging how much I owe to your example, and to the exertion of your friendly influence, from the time I took my seat

upon the pupils' benches, until I had the high honour of being appointed your colleague.

That your health may be preserved, so that our profession may, through a long series of years, possess you as an ornament; and Guy's Hospital long enjoy your assistance as its distinguished physician and teacher, is the sincere wish of

Your obliged and grateful friend,

GOLDING BIRD.

PREFACE

TO THE

FOURTH EDITION.

In preparing the fourth edition of this work for the press, I have anxiously endeavoured to render it as useful, and to give to it as practical a character, as possible. If in any case I may appear not to have noticed some of the more recent contributions to the literature of the profession on the now popular subject of urinary pathology, it has not been from oversight, or want of respect to their authors, but simply from their having been unsupported by my own observations.

Among many works which have lately issued from the press, I would, on all the surgical bearings of these subjects, draw attention to the practical value of Mr. Coulson's treatise on 'Diseases of the Bladder and Prostate Gland,' a most safe and useful guide to the management of these difficult cases. To the transla-

tion of Lehmann's 'Physiological Chemistry,' prepared for the Cavendish Society by my accomplished friend, Professor Day, of St. Andrew's, as well as to the 'Medical Chemistry' of Mr. S. E. Bowman, of King's College, I would refer for those minuter chemical details connected with humoral pathology, which are necessarily excluded from this work. To those who wish for an accurate guide to the microscopic appearances of the fluids of the body, and their crystalline elements, I would strongly recommend the beautiful and cheap series of drawings ('Atlas der Physiologischen Chemie'), by Dr. Otto Funke, of Leipsic.

I cannot but feel that the subject matter of the last chapter demands some explanation, and I fear it may be thought that I have introduced it without its possessing sufficient connection with the pathology of urinary deposits. The subject of a more rational and philosophical system of therapeutics, one more consistent with an inductive plan of inquiry than we at present possess, has for many years been with me a cherished idea, and I had hoped to have been permitted to have contributed something to the common stock of knowledge on this subject, one of the most important in its bearings on our mission of alleviating the distresses of sickness, and of combating the effects of disease. Severe and protracted illness, with which it pleased Divine Providence to visit me in the early

part of the past year, rendered a diminution of labour, and a more limited devotion to the duties of my profession imperative. I have been, therefore, made deeply sensible that such an inquiry must fall into other and more vigorous minds and abler hands. Still I hoped, that a brief summary of what I had been able to make out respecting the action of some diuretic agents, might appear in these pages without censure.

I now send forth this edition with deep feelings of gratitude for the kindness with which the three previous impressions have been received.

48, Russell Square,
February, 1853.

PREFACE

TO THE

THIRD EDITION.

ANOTHER edition of this work having been called for (the last having been out of print for nearly a year), I have endeavoured to amend and improve it as far as my more extended experience has permitted. Anxious not to increase its bulk, I have re-written rather than added; and in offering this edition to the notice of my professional brethren, it is my urgent desire that it may be found more worthy of the favour and patronage they have so generously accorded to the two previous impressions.

During the past year, science in general, and this branch of medicine in particular, has experienced an irreparable loss in the death of that sound philosopher, accomplished physician, and amiable man, Dr. Prout,

To his labours we are indebted for the existence of urinary pathology as a science, and we owe to him very many of the vast results which have of late years made organic chemistry so rich a field of observation. For it may well be doubted whether the renown of a Liebig, as well as of other illustrious physiological chemists, could have ever attained its present deserved eminence, had not the fallow ground of organic analysis been broken up by the patient industry and untiring energy of our late distinguished countryman. Only those who commenced their studies in organic chemistry previous to the last fifteen years, can have any idea of how much we owe to Dr. Prout, and they can never appreciate the enormous amount of difficulties he had to contend with.

Commencing his task at a time when the atomic theory was hardly generally admitted, when the laws of chemical combinations were very imperfectly known, he had not only to carry investigations, over which the beacon-light of previous labourers was so dim, as merely to show how little was known; but he had to invent and contrive his very means of research. Yet his zeal was so tempered with prudence, and an ardent love of truth, that the accuracy of nearly all the results of ultimate analysis made by him more than thirty years ago, remain unimpeached by the recent observations of the most celebrated chemists, aided

by all the refinements of our present means of investigation.

Dr. Prout's name will descend to posterity as that of one who has not lived in vain,—of one who has left us a noble example of scientific zeal, curbed by caution, of patient labour guided by a logical mind, and of extensive acquirements rendered more attractive by the modesty of their possessor.

48, Russell Square,
March, 1851.

ANALYTICAL INDEX.

CHAPTER I.

PRELIMINARY SKETCH OF THE CHEMISTRY OF THE URINE.

CHAPTER II.

PHYSIOLOGICAL ORIGIN AND PHYSICAL PROPERTIES OF URINE.

CHAPTER III.

CHEMICAL PHYSIOLOGY OF THE URINE.

CHAPTER IV.

CHEMICAL PATHOLOGY OF URIC ACID.

CHAPTER V.

CHEMICAL PATHOLOGY OF URIC OXIDE.

CHAPTER VI.

CHEMICAL PATHOLOGY OF PURPURINE.

CHAPTER VII.

CHEMICAL PATHOLOGY OF CYSTINE.

CHAPTER VIII.

CHEMICAL PATHOLOGY OF HIPPURIC ACID.

CHAPTER IX.

CHEMICAL PATHOLOGY OF OXALATE OF LIME.

CHAPTER X.

CHEMICAL PATHOLOGY OF THE EARTHY SALTS.

CHAPTER XI.

CHEMICAL PATHOLOGY OF ABNORMAL PIGMENTS.

CHAPTER XII.

PATHOLOGY OF NON-CRYSTALLINE ORGANIC DEPOSITS.

CHAPTER XIII.

THERAPEUTIC ACTION OF REMEDIES INFLUENCING THE FUNCTIONS OF THE KIDNEYS.

CHAPTER XIV.

BLOOD DEPURATION BY THE KIDNEYS AS A REMEDY IN DISEASE.

URINARY DEPOSITS,

THEIR

DIAGNOSIS, PATHOLOGY, &c.

CHAPTER I.

PRELIMINARY DETAILS CONNECTED WITH THE CHEMISTRY OF THE URINE.

Demonstration of the chief constituents of the urine, 1-13—Mucus, 3—Uric acid, 4—Urea, 5—Creatine, creatinine, 6—Colouring matter, 7—Hippuric acid, 8—Sulphuric acid, 9—Chlorine, 10—Phosphate of magnesia, 11—Lime, 12—Crystalline salts, 13—Quantitative general analysis, 13-15—Apparatus required, 16—Estimation of solids, 17—of urea, 18—of uric acid, 19—of inorganic salts, 20—*Clinical examination of urine*, 22—Non-sedimentary urine, 23—Sedimentary urine, 24—General rules for discriminating deposits, 25—Tabular analysis, 26—Microscopes, 27—Pillischers' lenticular microscope, 28.

1. As it is probable that many practitioners into whose hands this volume may fall, have not had many opportunities of becoming familiar with the chemistry of urine, nor more than acquainted by name with its chief constituents, I have thought the following introductory remarks might not be unacceptable. It is indeed quite essential that every one, who purposes making himself

28

acquainted with the important bearings of urinary pathology on the practice of his profession, should be at least acquainted with the characteristics of the most important constituents of the secretion. I would therefore advise the student to carefully repeat the processes described in the following paragraphs (2—13) before proceeding further, with the assurance that his subsequent researches will be thereby much facilitated, and the whole subject rendered much more intelligible.

A. *Demonstration of the chief constituents of the urine.*

2. In suggesting the following directions for enabling the reader to become personally acquainted with the most important ingredients of the healthy urine, I am anxious to be regarded as addressing those who are complete novices in chemical manipulations. Directions of this kind are of course quite useless to the adept. By the processes described in the following pages, any one can satisfy himself of the existence of the most important elements of the urine with a very small expenditure of time and trouble, and with no greater amount of chemical knowledge than necessarily falls to the lot of every practitioner of medicine.

The urine chosen for examination should be some passed into a glass vessel immediately on rising from bed.

3. Examine the urine by holding it between the eye and the light, a delicate cloud of *mucus* (331) will be observed floating in it. On passing the urine through a paper filter, the mucus will be left upon it in a thin varnish-like layer.

4. Gently warm about an ounce of the urine, concentrating it, unless it be already of moderately high specific gravity, to half its bulk; pour it into a conical

wine-glass, in which a few drops of hydrochloric acid have been previously placed, and set it aside. In a few hours a thin crystalline pellicle, varying in hue from a reddish brown, to almost perfect black, will be observed on the surface; this, on agitation, breaks up and falls in minute crystals to the bottom of the vessel. A drop of the fluid containing these crystals should be placed on a slip of glass and examined by the microscope. The fascicular and laminar crystals of *uric acid* will be readily recognised (fig. 1). The crystals thus obtained, being

Fig. 1.

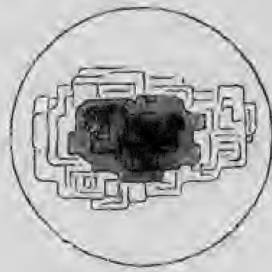

Fig. 2.

impure, must be washed with water, dissolved in a few drops of hot potash, filtered, cooled, and treated with hydrochloric acid to excess, and the crystalline deposit then examined.

5. Place about a teaspoonful of urine in a watch-glass, and evaporate it to about one third its bulk by the heat of a lamp. When cold, add an equal bulk of colourless nitric acid; in a few seconds crystals of nitrate of *urea* will fill the vessel. If they be collected on blotting-paper and dried by pressure, they will present a fine satin-like lustre, resembling, under a lens, laminæ of mother-of-pearl (fig. 2). Even this little trouble may be saved by placing a drop of urine on a plate of glass,

and adding to it an equal quantity of nitric acid. In a space of time, varying from a few minutes to half an hour, a solid white mass of satin-like lustre will be left, chiefly composed of nitrate of urea.

6. Evaporate an ounce of urine to a syrupy consistence, and allow it to cool. Carefully decant, after a few hours' repose, the dense supernatant fluid from the deposited salts. Warm it in a watch-glass, and dissolve in it a piece of fused chloride of zinc, the size of a small pea, and set the whole aside for twenty-four hours. On then examining it, a deposition of minute granular crystals will be observed. They consist of a triple compound of zinc and chlorine, with *creatine* and *creatinine*. Under the microscope their appearance is quite characteristic (fig. 3), consisting of radiating crystals like

Fig. 3.

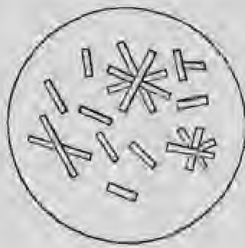

Fig. 4.

minute zeolites, and exhibiting beautiful coloured rings by polarized light. Their crystalline form becomes more obvious by dissolving them in a drop of water on a slip of glass over a spirit-lamp, and allowing the solution to evaporate spontaneously. These crystals were formerly mistaken for those of lactate of zinc, from which they differ most completely. This salt crystallizes in rhombic prisms (fig. 4), and does not present the radiating struc-

ture. Liebig proposes the following method of obtaining creatine from fresh urine: Treat the urine with lime-water and chloride of calcium, to precipitate the phosphates, filter the liquor, and separate the crystalline inorganic salts by evaporation. Treat the decanted liquor with chloride of zinc, and allow it to stand for a few days; a mass of crystals will then be obtained, consisting of creatine and the triple compound alluded to above. Dissolve the crystals in boiling water, and treat them with hydrated oxide of lead, until there be an alkaline reaction. Remove the oxide of zinc and chloride of lead by filtration, free the fluid from the lead and colouring matter by means of animal charcoal, and evaporate to dryness. Treat the residue, which consists of creatine and creatinine, with boiling alcohol, which takes up the creatinine and leaves the creatine. The crystals, which are very distinct, are represented below from a specimen prepared by Dr. A. Clark. Being thick, they cannot be perfectly shown without altering the focus during the examination (fig. 5).

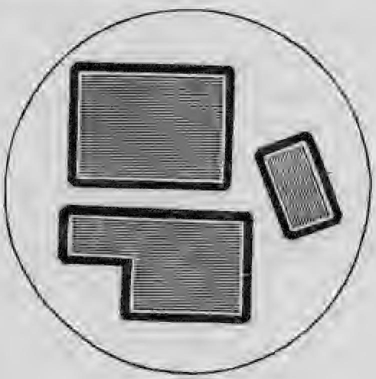

Fig. 5.

The creatinine may be obtained from the alcoholic solution mentioned above, and the crystals assume the following form: they are taken from a plate in Dr. Hassall's paper in the twenty-third number of the 'British and Foreign Medico-Chirurgical Review' (fig. 6).

Fig. 6.

7. Fill a test-tube one third full of urine, boil it over a lamp, and add immediately one fourth its bulk of hydrochloric acid. The production of a fine pink or purple colour will at once demonstrate the existence of the peculiar carbonized *colouring matter* of the urine (100).

8. Hippuric acid exists in too small a quantity to allow of its detection in human urine. As it is, however, quite necessary to be acquainted with its appearance, a small quantity of the urine of a horse or cow should be obtained for its demonstration. For this purpose, fill a watch-glass with the urine of one of these animals, and evaporate it over a spirit-lamp to one half or one fourth of its bulk. When nearly cold, add an excess of hydrochloric acid, taking care not to lose the mixture from the violence of the effervescence. Set the whole aside, and in a few hours, beautiful linear, and generally branched

crystals of *hippuric acid* will have formed, often so abundant as to render the whole nearly solid (203). Collect these crystals, wash them with a little cold water, dissolve them in boiling water, filter the solution, and set it again aside to crystallize; when crystals of pure hippuric acid may be obtained.

9. Add to some urine in a test-tube, a small quantity of dilute nitric acid. On then pouring in a solution of nitrate of baryta, a white precipitate of sulphate of baryta will fall, thus indicating the presence of *sulphuric acid*.

10. Having in the preceding experiment added nitrate of baryta until all the sulphuric acid has been precipitated in combination with the earthy base, pour the whole on a filter. On adding to the clear fluid which passes through, a solution of nitrate of silver, the production of a dense white precipitate, insoluble in nitric acid, will demonstrate the presence of *chlorine* (114).

11. Place a drop of the urine on a slip of glass, touch it with a glass rod dipped in liquor ammoniæ, and after two or three minutes' repose cover it with a piece of thin glass. Place it under the microscope, and the beautiful and highly characteristic crystals of the combinations with *phosphoric acid*, with *magnesia*, and ammonia, in elegant stellæ (fig. 7), will at once indicate the existence of the two former substances (106).

Fig. 7.

12. Place a drop of urine, as in the last experiment, on a piece of glass, and add a drop of a solution of oxalate of ammonia. A cloud will immediately form from the precipitation of oxalate of *lime*, and on examining this, after an hour's repose, under the microscope (using an object glass of at least one-fourth-inch focus), it will be found to be composed of minute cohering crystals, each presenting a square outline (214—218).

13. Place a few drops of urine carefully in the centre of a slip of glass, and evaporate them to dryness. When nearly dry, examine them under the microscope, and little octohedra of *chloride of sodium* will be visible. The urine passed shortly after breakfast is usually the best for exhibiting the crystallization of the salts of the secretion, as it contains less organic matter than that passed at other times of the day. A few drops of such urine examined after evaporation on a glass plate exhibits very beautiful crosslets and daggers, variously modified, of chloride of sodium (fig. 8): mixed with these, den-

Fig. 8.

tritic and plumose crystals of *phosphate of soda* are frequently visible. Some of these have been described as consisting of hydrochlorate of ammonia; but as they can easily be obtained from a solution of the ashes of urine, they cannot possibly be composed of this salt. In fig. 9

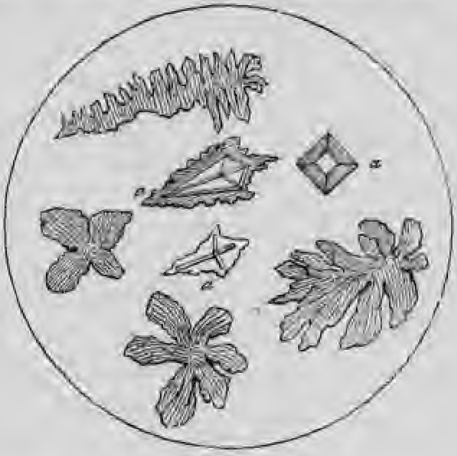

Fig. 9.

is a microscopic representation of the crystals left by the evaporation of a drop of the watery solution of the ashes of urine. The crystals marked *a* are those of chloride of sodium; the others consist of the tribasic alkaline phosphate of soda, formed by the process of incineration from the rhombic salt (107). I have never met with any satisfactory evidence of the presence of crystals of hydrochlorate of ammonia in the residue of the evaporation of urine; although there can be no doubt of the frequent presence of small quantities of that salt in the urine.*

* Dr. Marcet, in the twenty-second number of the 'British and Foreign Medico-Chirurgical Review,' has detailed the description of two new acids

14. In this manner the existence of the following constituents is demonstrated in urine:

Urea	By experiment	5
Uric acid		4
Creatine and Creatinine		6
Colouring matter rich in carbon		7
Hippuric acid		8
Mucus		3
Chlorine		10
Sulphuric acid		9
Phosphoric acid		11,13
Lime		12
Magnesia		11
Chloride of sodium		10,13
Phosphate of soda		13

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which he has detected in human urine. He states that after the extraction of urea by the addition of ether to the alcoholic solution of dried urine, the strongly acid mother-liquor is evaporated at a low temperature, baryta water being previously added, to avoid the decomposition of the organic substance contained in the solution. The acids are then set free by the addition of sulphuric acid in excess to the remaining aqueous solution, which is shaken in a flask with alcohol and ether, and allowed to stand; the ether soon rises to the surface, possessing an acid reaction, though not from the presence of the sulphuric acid, as it remains, with the small quantity of urea left behind by the first operation, dissolved in an inferior layer of water. The supernatant ethereal solution is decanted, and repeatedly washed with water and alcohol, ether being occasionally added to supply the deficiency caused by evaporation during the above-mentioned process. An acid solution in ether is finally obtained quite free from urea and sulphuric acid, and remarkable for its beautiful pink colour when observed under transmitted light. Decant the solution for the last time through a filtering funnel, and allow the inferior layer of water to run out; and then evaporate the acid ether at the temperature of the atmosphere. Twelve hours afterwards the remaining liquid is found covered with prismatic colourless needles, which can be collected and dried upon filtering paper, and the sides of the vessel are covered by an amorphous pink deposit.

First acid. The crystalline substance, when examined under the microscope, appears to assume the form of oblique rhombohedra, or of prisms

B. *General analysis of urine containing no abnormal ingredients.*

15. An accurate analysis of the urine constitutes one of the most difficult problems in chemistry, and can only

derived from that type, aggregating occasionally in stellate groups, but generally branching off from a main crystal or long prism. The crystals transmit readily polarized light, are soluble in ether, alcohol, and boiling water; the solution has an acid reaction, and again deposits crystals in concentration.

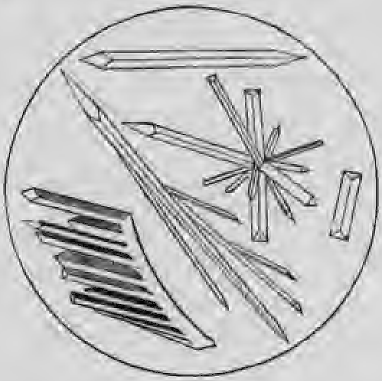

Fig. 10.

When heated upon a platina spatula, the crystals fuse, emitting a peculiar smell, different from that of hippuric acid, and after charring, without taking fire, finally disappear without residue. This substance, therefore, is not hippuric acid, to which, however, in many respects, it bears great analogy.

Second acid. The pink deposit, which occurs on the sides of the vessel during the evaporation of the mother-liquor, has a very strong acid reaction; after standing for a week it is found to contain colourless concentric groups of radiating crystals; but the very small quantity obtained did not admit of their minute examination. Robin considers the pink amorphous sediment as *urrosacine*, or the colouring principles of urine obtained by Dr. Harley. This pink substance is soluble in ether and alcohol, but not in water. Its smell is peculiarly aromatic, increasing when exposed to heat on a platina spatula; it chars, emitting an odour of burnt oil, and leaves no appreciable fixed residue. We have not observed whether iron is present [138].

be undertaken, with any approach to accuracy in the results, by the experienced chemist. A minute investigation of this kind is too frequently impracticable, from its involving an expenditure of time and attention wholly out of the reach of those who are actively engaged in practice. It is, however, fortunate that almost all the really useful information capable of being yielded by a knowledge of the composition of the urine, can be attained by a mode of analysis easy in performance, requiring merely common care for its success, and no considerable amount of chemical tact, skill, or sacrifice of time. This is effected by limiting the examination to the isolation of those ingredients which are of the most recognised pathological importance, rejecting those which exist in small quantities, and which, so far as we yet know, present no practical indications. By availing himself of processes of this kind, every practitioner could readily contribute most important additions to the present meager state of chemical pathology with an almost nominal amount of trouble and chemical skill.

16. Presuming that the practitioner possesses no chemical apparatus, it will be very necessary for him to procure the following, which will require the outlay only of a few shillings:

Griffin's earthenware lamp-furnace.*

A glass funnel and good filtering paper of firm texture.

A Berlin porcelain crucible holding about an ounce.

A couple of Berlin evaporating dishes fitting the opening of the water-bath of the furnace.

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* Messrs. Griffin, of 119, Bunhill Row, have arranged the necessary apparatus and reagents required in these researches in a very convenient and economic manner.

A conical precipitating glass, or plain wine-glass.
A few watch-glasses and test-tubes.
A small gravimeter (urinometer) for taking specific gravities.

The balance required need not be an expensive one. One turning readily with a quarter of a grain, when loaded with an ounce, will be sufficiently delicate.

17. Place the urine in a cylindrical glass, and immerse the gravimeter; the specific gravity thus discovered will, by a reference to the tables (55) (59), show the weight of a fluid ounce in grains, and the proportion of solid matter in that quantity, as well as in 1000 parts. Where great accuracy is desired, it will be proper to check this information by evaporating a fluid ounce of the urine to as near dryness as possible by means of a water-bath (18), and weighing the residue. This process, simple as it appears, is really one of extreme difficulty, and so obstinately are the last portions of water retained, that it can scarcely be satisfactorily effected without the aid of an air-pump, so as to complete the operation of drying the residue mass in vacuo, over sulphuric acid or quick lime.

18. Pour a carefully measured fluid ounce of the urine into a porcelain capsule (*a*), fitting into the opening of an earthenware water-bath (*b*), about half full of hot water. Place this apparatus on the top of the earthen cylinder (*c*) of Griffin's lamp furnace. A lighted spirit- or oil-lamp being introduced into the latter, the water in the bath will soon boil, and its vapour condensing on the bottom of the capsule (*a*), will cause its contents to evaporate without risk of loss by the production of violent ebullition or burning. When the urine has evaporated to about a fluid drachm, lift the capsule from the bath, and allow it

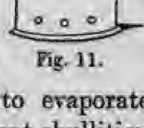

Fig. 11.

to cool. While cooling, it will become opaque from the deposition of saline matters, especially of phosphates and urates. When cold, fill the water-bath with water, containing some pieces of ice, or, if the ice is not at hand, a mixture of three drachms of finely powdered nitrate of potass, and as much hydrochlorate of ammonia stirred into the water as a substitute for the ice. Care must be taken that enough water is present to reach the bottom of the capsule containing the inspissated urine, when fitted to the aperture of the bath. Having then replaced the capsule, carefully add half a fluid drachm of cold colourless nitric acid, stirring the mixture with a glass rod; only a slight effervescence will occur, if the apparatus be kept sufficiently cool, and the whole will become nearly solid, from the formation of crystalline scales of nitrate of urea. Place the crystalline mass on a properly folded filter of strong bibulous paper, supported on a glass funnel, and gently drop on it a very small quantity of ice-cold water in a very slender stream. When nearly drained, carefully raise the filter from the funnel, and, gently opening it, place it on the smooth surface of a porous brick. In a few hours the nitrate of urea will be found nearly dry in a slightly cohering mass, capable of being easily detached from the paper. It should be carefully removed into a capacious watch-glass, and after being kept for an hour in a warm place, it should, before becoming quite cold, be carefully weighed. 100 grains of the impure nitrate thus procured indicate very nearly 48 grains of urea.* Liebig has suggested a very inge-

* Concentrate about a couple of ounces of filtered urine to a syrupy consistence, and then add finely powdered oxalic acid in considerable excess, or until the last added portions remain undissolved. On cooling, the whole will become nearly solid from the precipitation of oxalate of urea. Collect the

nious method for determining volumetrically the amount of urea in the urine, which has close connection with a chemical fact, recently observed by himself—that if chloride of mercury (corrosive sublimate) in solution, and bicarbonate of potash in excess, be added to a solution of urea, we obtain a compound of urea and mercury, ($\overset{+}{U}$+4HgO), which is perfectly insoluble in water. This method has further this advantage, that we simultaneously determine the amount of *chlorine* in the urine. The following are the main steps in the process: In order to remove the phosphates and sulphates of the urine, a definite quantity of the fluid is mixed with half its volume of a fluid containing one volume of a saturated solution of nitrate of baryta to two volumes of a saturated solution of caustic baryta. We take about 15 cc. of the filtered alkaline fluid (which consequently contains for

semi-solid mass and submit it to considerable pressure between several folds of coarse filtering paper, when a hard dry residue will be left. Transfer this dried cake, with the least possible amount of breaking, into a test-tube, and add rather more than an equal bulk of cold distilled water, agitate gently, and after some little time pour away the liquid, boil the residue in water, and filter the hot solution. Boil the filtrate with a little animal charcoal, and then add gradually some finely powdered chalk as long as any effervescence is produced; filter and evaporate the clear liquid in a water-bath. This liquid is an aqueous solution of urea, which, when evaporated to a small bulk, will deposit crystals. The crystallization may be effected on a glass slide, and the result examined microscopically. Urea appears sometimes in the form of white silky needles, sometimes in the form of flattened four-sided prisms, containing numerous cavities [159].

Dr. Davy has recommended the following simple and accurate method of determining the amount of urea. Pour a measured quantity of urine into a graduated tube partly filled with mercury, add an excess of the hypochlorite of soda, and invert the tube. In a few seconds decomposition of the urea commences, the carbonic acid is absorbed by the hypochlorite, and the nitrogen collects in the upper part of the tube, from which can easily be calculated the amount of urea [160].

every three volumes two volumes of urine), and then, without neutralizing it, we add from a burette a solution of nitrate of protoxide of mercury of known strength, as long as any precipitate is formed. The mixture must be well stirred during the process. The precipitate is the above-mentioned compound of urea and protoxide of mercury ($\overset{+}{U}+4HgO$). When a few drops of the turbid fluid are poured into a watch-glass, and one drop of a solution of carbonate of soda is added, the mixture soon becomes yellow, when treated with an excess of the solution of mercury, but it remains white when the solution of mercury is insufficient to precipitate all the urea. Very different methods may, of course, be employed for the preparation of the test-fluid (of nitrate of protoxide of mercury); Liebig has, however, proposed a very simple method for this purpose, which depends upon the fact that nitrate of the protoxide is decomposed by phosphate of soda, but that chloride of mercury (corrosive sublimate) is not thus affected. If, however, a solution of common salt, of known concentration, be added to a mixture of these salts, before the precipitate of the phosphate of mercury has become crystalline, the quantity of the oxide of mercury may be very easily calculated from the volume of chloride of sodium necessary for its re-solution; for one equivalent of chloride of sodium necessarily corresponds to one equivalent of the phosphate of mercury. We may, however, at once obtain a solution of chloride of sodium, suited for the purpose of these experiments, when we consider that a solution which is saturated between the temperatures of 0° and 100° C. constantly contains 27% of salt.

"The method of determining the amount of *chlorine* in the urine is based upon the fact that, on the one hand, urea may be precipitated by the nitrate or protoxide, but

not by the chloride of mercury; and, on the other hand, that the nitrate becomes converted into the chloride of mercury, when brought into contact with chloride of sodium. In order, therefore, to find the amount of chlorine in the urine, a definite volume of it should be decomposed with the solution of baryta; the urine which is filtered from the precipitate should then be treated with nitric acid until it is completely neutralized, and the solution of the nitrate of mercury poured upon it until the precipitate no longer dissolves on being stirred, that is to say, as long as the chloride of mercury is formed. The quantity of the chloride of mercury, or of the chlorine contained in the urine, may be calculated from the volume of the solution of mercury which has been used.

"Liebig found that this method of determining the urea was equally efficacious with putrefied urine, provided decomposition has not proceeded too far. Dr. Limpricht has found that allantoine is also precipitated by nitrate of protoxide of mercury, but allantoine has never yet been discovered in normal or morbid *human* urine. Frerichs and Städder have found it in the urine of dogs, when respiration was impeded."*

19. A fluid ounce of the urine should be gently warmed and poured into a conical glass, in which about 30 drops of hydrochloric acid has been previously placed. The mixture being stirred with a glass rod, and covered with a piece of paper to exclude the dust, must then be set aside for 12 hours. The uric acid will be found partly floating in a pellicle on the surface, and partly precipitated on the sides of the glass in dark-coloured grains. The whole is to be well stirred with a glass rod, so as to excite a vortiginous motion in the fluid, aided

* Lehmann, 'Physiological Chemistry,' quoted in the Report on Chemistry by Dr. Day, in the 'Medico-Chirurgical Review,' No. xxx, p. 541.

by which all the uric acid will in a few moments fall to the bottom of the glass. The supernatant fluid should be decanted and replaced by distilled water. After repeating this process three or four times, the precipitated acid may be washed with a few drops of water into a watch-glass, dried, and weighed. We thus learn the amount of uric acid existing in a fluid ounce of urine. Uric acid cannot be obtained in any quantity from healthy human urine. The best method of preparing it is that given by Bensch: "The excrements of serpents or birds, or calculi of uric acid, are boiled in a solution of one part of hydrate of potash in 20 parts of water till ammoniacal fumes cease to be evolved. A current of carbonic acid is now passed through the solution till the fluid almost ceases to have any alkaline reaction. The precipitated urate of potash is washed with cold water till it begins to dissolve; on now dissolving this potash salt in a solution of potash, warming it, and pouring it into an excess of warmed hydrochloric acid, we obtain a precipitate of pure uric acid" [161].

Fig. 12.

20. Evaporate an ounce of urine in a capsule (*a*) over a spirit-lamp (*b*) without the interposition of the vapour-bath, and when reduced to about a teaspoonful, pour it into a porcelain crucible (*d*), washing the capsule in which the evaporation is performed with a few drops of water, which are to be added to the contents of the crucible. By aid of the spirit-lamp, heat is to be applied until the contents of the crucible are dry and beginning to char. It should then be carefully placed in a little space made for it in the centre of a clear, smokeless, and flameless fire. Allow the crucible to remain at a bright red heat for ten minutes, then carefully lift off the lid,

taking care that no dust falls into the vessel, and in three or four minutes remove the crucible itself. It should be allowed to cool on a brick or on sand, to avoid its fracturing by too sudden change of temperature. When cold a nearly white fused mass will be found, consisting of the combinations of sulphuric acid, phosphoric acid, and chlorine, with lime, magnesia, and soda or potash, or their metallic bases. The weight of these salts can then be determined. If it be desired to calculate the proportion of earthy and alkaline salts, it can be easily effected by reducing the fused mass to powder, and digesting it in water, by which the chloride of sodium and tribasic phosphate of soda, with any alkaline sulphate, will be dissolved, and the phosphates of magnesia and lime will be left. The weight of the latter, when quite dry, subtracted from the weight of the fused mass, will of course give the proportion of alkaline salts present.

By the above process we have learned—

The aggregate amount of solids	17	In a fluid ounce of urine.
,, ,, of urea	18	
,, ,, of uric acid . . .	19	
,, ,, of inorganic salts . .	20	

21. By deducting the aggregate weight of the urea, uric acid, and salts, from that of the total quantity of solids, the weight of the mixture of what has been denominated extractive matters may be learnt. This so called extractive matter contains the peculiar colouring matter (of which, indeed, it is probably principally composed), hippuric acid, the nitrogenized substance of Pettenkofer (93) or creatinine, with lactic acid* (if really existing in urine), and perhaps combinations of ammonia.

* Lehmann, with Berzelius, during his later years, entertains no doubt of the presence of lactic acid in human urine. Boussingault has detected lactic

On multiplying the quantities thus obtained by the number of ounces of urine secreted in 24 hours, the proportion of the different matters separated in that time by the kidneys will of course be learnt.

I venture to hope that the process for analysis thus detailed is sufficiently simple and easy of execution to induce practitioners to make themselves conversant with it. How much valuable information would be collected in a few years if every member of the profession would thus examine, every second or third day, the urine of but one patient during the entire course of any well-marked ailment, as fever, the exanthems, rheumatism, &c.

C. *On the clinical examination of the urine.*

22. The following observations may be of service to the practitioner, both as a guide to his proceedings in the superficial examination of the urine, the most important part of which can be readily performed in a few moments in the sick-room; and as a reference to the contents of this volume, which will direct him to the completion of his investigations when at leisure. Premising that the urine presented for inspection is either an average specimen of that passed in the preceding twenty-four hours (49), or at least that resulting from the first act of emission after a night's rest (51), unless the urine secreted at other times of the day be specially required.

A. Urine without any visible deposit, or decanted from the sediment.

23. A piece of litmus paper should be immersed in the

acid in the urine of pigs fed with potatoes, as well as in that of cows and horses.

urine, which, if acid, will change the blue colour of the paper to red. Should no change occur, a piece of reddened litmus paper must be dipped in, and if the secretion be alkaline, its blue colour will be restored: but if its tint remains unaltered, the urine is neutral.

Some of the urine should then be heated in a polished metallic spoon over a candle, or, what is preferable, in a test-tube over a spirit-lamp (317), and if a white deposit occurs, albumen,* or an excess of the earthy phosphates is present; the former, if a drop of nitric acid does not re-dissolve the deposit, the latter, if it does.

If the urine be very highly coloured, and not rendered opaque by boiling, the colouring matters of bile, or purpurine, are present. To determine which, pour a thin layer of urine on the back of a white plate, and allow a few drops of nitric acid to fall in the centre: an immediate and rapidly ending play of colours, from bluish-green to red, will be observed if bile (61), but no such change will be observed if purpurine (101, 182) alone exists. Should the highly coloured urine alter in colour or transparency by heat, the presence of blood must be suspected (321).

If the addition of nitric acid to deep red urine, unaffected by heat, produces a brown deposit, an excess of uric acid exists. If a specimen of urine be pale, immerse the gravimeter, and if the specific gravity be below 1·012, there is a considerable excess of water, but if above 1·025, the presence of sugar, or a superabundance of urea, is indicated. To determine the existence of either of these conditions, place a few drops of the urine in a watch-glass,

* If the urine be alkaline heat will not always precipitate the albumen; it is requisite, therefore, before applying the heat, to render the urine slightly acid by means of acetic acid. The test-tube must be quite clean, as the presence of a minute quantity of nitric acid will interfere with the success of the experiment.

add an equal quantity of nitric acid, and allow the glass to float on some cold water; crystals of nitrate of urea will appear in two or three minutes, if the latter exists in excess (72). Should this change not occur, the urine must be examined specially for sugar, which, it must be remembered, may exist in small quantities, without raising the specific gravity of the fluid. For this purpose boil a small portion with an equal bulk of liquor potassæ in a test-tube, and the development of a brown colour will at once afford evidence of the almost certain existence of sugar (351). An excess of colouring matter, rich in carbon, should always be sought after, on account of its pathological importance. This is readily done by boiling some urine in a tube, and, whilst hot, adding a few drops of hydrochloric acid. If an average proportion of the pigment exist, a faint red or lilac colour will be produced; but if an excess is present, it will be indicated by the dark red or even purple tint assumed by the mixture (101).

Should the urine be alkaline, add a drop of nitric acid; if a white deposit occurs, albumen is present (317); if brisk effervescence follows the addition of the acid, the urea has been converted into carbonate of ammonia (77).

B. Examination of the sediment deposited.

24. If the deposit be flocculent, easily diffused on agitation, and scanty, not disappearing on the addition of nitric acid, it is chiefly made up of healthy mucus (331), epithelial débris (341), or occasionally, in women, of secretions from the vagina, leucorrhœal discharge (328), &c.

If the deposit be ropy and apparently viscid, add a drop of nitric acid; if it wholly or partly dissolve, it is composed of phosphates (259), if but slightly affected, of

mucus (331). If the deposit fall like a creamy layer to the bottom of the vessel, the supernatant urine being coagulable by heat, it consists of pus (328).

Urine sometimes appears opaque, from the presence of a light flocculent matter diffused through it, neither presenting the tenacity of mucus, nor the dense opacity of pus. Although scarcely sufficient in quantity to interfere with the perfect fluidity of the urine, if a little be placed in a test-tube, and agitated with an equal bulk of liquor potassæ, the mixture will often become a stiff transparent jelly. This peculiar appearance is demonstrative of the presence of the exudation, or large organic globules (338), formed under the influence of irritation, providing the urine does not coagulate by heat, for should it do so, the existence of minute quantities of pus may be suspected.

If the deposit be white, it may consist of urate of ammonia,* phosphates, or cystine; the first disappears on heating the urine (130), the second on the addition of a drop of diluted nitric acid (255), whilst the third dissolves in ammonia (188), and the urine generally evolves an aromatic odour like the sweet-briar, less frequently being fetid.

If the deposit be coloured, it may consist of red particles of blood, uric acid, or urate of ammonia† stained with purpurine. If the first, the urine becomes opaque by heat (317); if the second, the deposit is in visible crystals (124); if the third, the deposit is amorphous, and dissolves on heating the fluid (130).

* Lehmann and Heintz, and Dr. Letheby, whose experiments I have quoted in a later page, have determined that this deposit consists of urates of soda, potash, lime, magnesia, and a small quantity of ammonia.

† See preceding note.

Oxalate, and more rarely oxalurate (?) of lime are often present diffused through urine, without forming a visible deposit; if this be suspected, a drop of the urine examined microscopically will detect the characteristic crystals (214).

If the urine be opaque like milk, allowing by repose a cream-like layer to form on the surface, an emulsion of fat with albumen is probably present. Agitate some of the urine with half its bulk of ether in a test-tube, and after resting a few minutes, a yellow ethereal solution of fat will float on the surface of the urine,—a tremulous coagulum of albumen generally forming beneath it (370).

25. Much of the little time required for the investigation thus sketched out, may be saved by remembering the following facts:

If the deposit be white, and the urine acid, it in the great majority of cases consists of urates; but should it not disappear by heat, it is phosphatic.

If a deposit be of any colour inclining to yellow, drab, pink, or red, it is almost sure to be urates, unless visibly crystalline, in which case it consists of uric acid.

26. The following tables briefly point out the readiest mode for the examination of crystalline deposits, both by chemical tests and by microscopic examination. The latter mode is of course preferable to all others, both for the accuracy and extent of the information it affords, as well as for economy of time—

A. *Table for discovering the nature of urinary Deposits by chemical Re-agents.*

If the deposit be white and soluble by heat	It consists of	urates.*
" " insoluble by heat, but soluble in ammonia . .	"	cystine.
" " " and ammonia, but soluble in acetic acid . . .	"	earthy phosphates.
" " " ammonia, and acetic acid . .	"	oxalate or oxalurate of lime.
" be coloured and visibly crystalline† . . .	"	uric acid.
" " and amorphous, but pale, and readily soluble by heat	"	urates.
" be deeply coloured, amorphous, and slowly soluble by heat .	"	urates stained by purpurine.

* The bases of uric acid are never single, but generally consist of soda, potash, magnesia, lime, and ammonia.

† Striated earthy flattened corpuscles, probably from the prostate, are occasionally found, and though not really crystalline may at first be supposed to be so.

B. *Table for the microscopic examination of Urinary Deposits.*

If the deposit be amorphous, and disappear on the addition of liquor potassæ .	It consists of urates.
" " and permanent after the addition of liquor potassæ	" phosphate of lime.
" visibly crystalline, and the crystals octohedral* . .	" oxalate of lime.
" visibly crystalline, and the crystals hexagonal tables soluble in ammonia	" cystine.
" visibly crystalline, and the crystals prismatic or simply penniform, not soluble in ammonia, but soluble in acetic acid .	" neutral triple phosphate.
" visibly crystalline, and the crystals radiated or foliaceous, not soluble in ammonia, but soluble in acetic acid, with effervescence	" carbonate of lime.
" visibly crystalline, and the crystals radiated or foliaceous, not soluble in ammonia, but soluble in acetic acid, without effervescence	" bibasic triple phosphate.
" visibly crystalline, and the crystals be dumb bells, not soluble in ammonia, but soluble in acetic acid, with effervescence .	" carbonate of lime.

* Arsenious acid, chloride of sodium, and protoxide of antimony assume the octohedral form; but are too rarely present to demand further notice.

If the deposit be visibly crystalline, and the crystals be dumb bells, soluble by heat, but not in ammonia nor acetic acid . .	It consists of urate of soda.
" visibly crystalline, and the crystals be dumb bells, insoluble by heat, ammonia, and acetic acid . . .	" oxalurate of lime.
" visibly crystalline, and the crystals be dumb bells, with fringed edges, insoluble in alcohol and acetic acid, but soluble in liquor potassæ	" uric acid.
" visibly crystalline, and the crystals lozenge-shaped, or compound, insoluble in acetic acid and ammonia . .	" uric acid.
" visibly crystalline, and the crystals spherical, with or without spicules, soluble by heat . . .	" urate of soda.

The sediment may be *organized*, and consist of mucus, pus, epithelial cells from the genito-urinary passages, semen, blood, casts of uriniferous tubes, various pathological cells, and the débris of disintegrated tissue.

If the deposit be stringy, coagulable by acetic acid, and consist of a tenacious matrix with cells, some of which are small and round, others large and flat, with oval nuclei, it is mucus.

If the deposit consist of spherical globules, not imbedded in a matrix, about $\frac{1}{1800}$th of an inch in diameter, studded with molecules and granules, and containing a double or triple nucleus on the addition of acetic acid, it is pus.

Epithelial cells, semen, blood, uriniferous casts, pathological cells, the débris of disintegrated tissue, and confervoid bodies, may be detected by their several microscopic appearances, which will be afterwards noticed. Indigo and deep colouring principles are sufficiently evident, but will receive more especial notice.

27. The microscope required for researches into the nature of urinary deposits may be one of very simple construction, so as not to involve unnecessary expense. Whatever, however, may be its other optical arrangements, it must always be provided with a good half-inch, or still better, quarter-inch achromatic object-glass. A very economical instrument of the kind is made at Paris by George Oberhaüser under the name of "Microscope pour l'hospice," which he sells for sixty francs. In this country these instruments are more expensive, but their mechanical arrangements are much superior. Mr. Ross (Featherstone Buildings), Mr. Powell (Seymour Place), and Messrs. Smith and Beck (Coleman Street), three of our most celebrated microscope-makers, sell a very efficient and excellent instrument with one object-glass for about seven pounds. Mr. Dancer, of Manchester, also manufactures a very complete and excellent instrument for about ten pounds. I think one of the most economical microscopes I have seen, was made by a German artist lately settled in London (Pellischer, New Bond Street), at the cost of seven guineas, a very portable instrument, furnished with two dial-glasses of a quarter-inch and an inch focal distance respectively. Mr. Ackland sells a good instrument for five guineas.

28. It has often been a matter of regret that a very portable microscope has not hitherto been contrived, sufficiently small to be easily carried in the pocket, and sufficiently economical to be within the reach of all. Very recently Mr. Pillischer has constructed one, which he terms the "lenticular microscope," which seems to me to fulfil this condition entirely, and I cannot too strongly recommend it to the notice of the profession. In the construction of this beautiful little instrument, he has made use of the excellent and well-known Coddington

lens, which consists of a very thick double convex lens excavated at the sides into a kind of dumb-bell shape, by which the extreme lateral rays are cut off, and a very perfect image obtained.

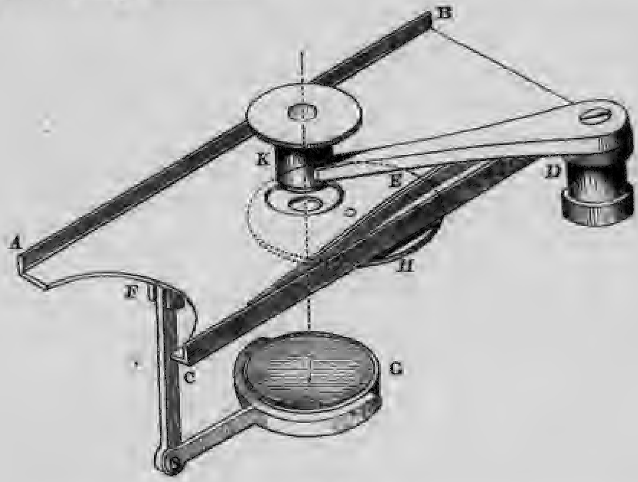

Fig. 13.

It consists of a rectangular piece of brass (A B C D), excavated at one end, furnished with raised sides. To the inner surface of the side C D a steel spring (E) is fixed, for the purpose of keeping the piece of glass on which the object is placed quite steady. At the under surface at F a brass arm is fixed bearing a small concave mirror (G). A perforated diaphragm (H) is fixed to a pin beneath an aperture in the plate, so that by moving it, the pencil of rays reflected from the mirror may be lessened, and a clearer definition obtained. D K is a strong arm of brass, capable of being moved horizontally over the aperture in the plate, whilst a fine screw move-

ment at D enables it to be raised vertically. The lenses, having respectively a focal length of about $\frac{1}{5}$, $\frac{1}{20}$, and $\frac{1}{75}$th of an inch each, are placed in a split cylinder (K) at the end of the arm (D K). When not in use the arm to which the mirror is attached is folded up flat against the under surface of the plate, and thus the whole apparatus can be carried in the waistcoat-pocket. To use this instrument, a drop of urine containing a deposit is placed on a slip of glass, and covered with a piece of mica or thin glass. It is then placed on the plate (A B C D), on which the spring firmly retains it. One of the lenses being then placed in the cylinder (K), the object is brought into focus by means of the screw (D). Illumination being effected by holding up the instrument to the light of the clouds or a candle, or still better by reflecting a ray of light through the object by means of the mirror. If the object is very translucent, especially when epithelial cells are searched for, the amount of transmitted light should be diminished by means of the diaphragm. Should the deposit consist of large coarse crystals, it is better placed in a little cavity ground in a plate of glass (which accompanies the instrument), as they will thus escape injury when covered with the piece of thin glass for examination.

CHAPTER II.

PHYSIOLOGICAL ORIGIN AND PHYSICAL PROPERTIES OF URINE.

29. It is a very common error to regard every deviation from the normal appearance of urine as an index of renal disease, and to assume every change of colour or transparency as an evidence of some ailment proper to the urinary organs. This error is by no means confined to the public, but has extended very generally among medical men. In by far the great majority of cases, however, the reverse is the truth, and these altered aspects of the urine are almost always to be traced to causes independent of local disease. The only view that can be legitimately taken of such conditions is to regard them, not as constituting entities of morbid action, but as part

of a series of pathological changes going on in the system, and of peculiar value as indications of disease, in consequence of the facility with which they can be detected. Hence every abnormal state of the secretion in question should be regarded rather as an exponent of some particular result of morbid action, than as constituting a substantive ailment.

It is true, that those pathological states of the urine which are accompanied by the deposition of sediments, or gravel, as they are popularly termed, may, and frequently do, go on to the formation of the much-dreaded stone or calculus; and thus have a claim, from their importance, to be regarded as definite and independent diseases. Still, both in their pathological and therapeutical relations, although frequently called upon, from the irritation they produce, to make the deposit or calculus the primary object of attention, yet we must never lose sight of the fact, that these are for the most part effects, not causes, the results of some morbid condition often remote from the bladder; the last links of a chain, of which it should be the endeavour of the physician to grasp the first.

Sources of the Urine.

30. In a physiological point of view, the urine may be regarded as arising from three several sources, each acting alike in preserving the equilibrium of the delicately adjusted balance of the secreting and depurating functions of the body. The effects of copious aqueous potations in producing a free discharge of pale urine, at once indicates one source of the great bulk of the urinary secretion, and demonstrates one of the most important functions of the kidneys in their pumping off any excess of fluid which may enter the circulation. A second great duty of these

organs is shown in the physical and chemical characters of their secretion after the digestion of food is completed. Here it is no uncommon circumstance to detect the presence of some traces of the elements of an imperfectly digested previous meal; and in unhealthy and irritable states of the chylo-poietic functions, to discover some abnormal constituent in the urine, arising from the incomplete assimilation of the recently digested food. Of the former of these states, the peculiar odour and colour of the urine after the ingestion of asparagus, seakale, and rhubarb afford an example; and a good illustration of the latter condition is met with in the copious elimination of oxalic acid from the blood shortly after a meal in some cases of irritative dyspepsia. It is, indeed, a general law, that any substance which has entered the circulating mass, and not being required for the nutrition of the body, nor forming a normal element of healthy blood, always escapes from the system by the kidneys, providing it exists in a state of complete solution. Hence these most important emunctories have the duty of removing any imperfectly assimilated elements of the food which have been absorbed while traversing the small intestines and entered the circulating mass; as well as excreting the often noxious results of unhealthy digestion. To effect these most important conditions, it is essential that the substance to be removed should be soluble, or at least capable of being readily metamorphosed into a body soluble in the water of the urine; as nothing can be excreted from the kidneys, without breach of surface, unless in a state of solution. The third function performed by the kidneys is their serving as outlets to evolve from the animal organism those elements of the disorganization of tissues which cannot perform any ulterior process in the economy, nor be got rid of by the lungs or skin. The disorganization

of tissues here alluded to is a necessary result of the conditions for the growth and reparation of the body.

31. It is well known that our bodies are always in a kind of transition state, that during each moment of our existence, every atom of the frame is undergoing some change or other; the old matter is absorbed and thrown off at one or other of the excreting outlets of the body, and new matter is deposited from the blood to supply its place. The old and effete atoms of the animal structure are not excreted in the form of dead tissue, but becoming liquefied they re-enter the circulation, their elements being re-arranged; one series of combinations thus produced, rich in nitrogen, is excreted by the kidneys, whilst those products which contain a preponderance of the inflammable elements, carbon, hydrogen, and sulphur, are called upon to perform, chiefly through the medium of the liver, an important office previous to their final elimination from the system. Thus, the blood is not only the source of the elements derived from the food which serve for the nutrition of the body, but it also serves, like a sewer, to receive the matter arising from the waste and liquefaction of the old and exhausted tissues.

32. We must therefore recognise, even in a state of health, three distinct varieties of the urinary secretion, each characterised by certain peculiarities: First, that passed some little time after drinking freely of fluids, generally pale, and of low specific gravity (1·003—1·009), *urina potus*. Second, that secreted shortly after the digestion of a full meal, varying much in physical characters and of considerable density (1·020—1·028, or even 1·030), *urina chyli vel cibi*. Third, that secreted from the blood independently of the immediate influence of food and drink, as that passed after a night's rest, *urina sanguinis*; this is usually of intermediate density (1·015—

1·025), and presents in perfection the essential characters of urine.

33. As we can thus trace the elements of the urine to a process by which the effete elements of the body are removed, it may be useful to inquire how far we are enabled to follow the exhausted tissues through their several changes until they disappear in the different excretions. It is true that, in the present state of our knowledge, it would be alike rash and presumptuous to dogmatically lay down any laws under which the changes alluded to occur, but it cannot be denied that we begin to see a glimmering of light apparently in the right direction, and some few stages in these wonderful results of vital chemistry are becoming visible. At all events, enough now has been done, more especially by the illustrious head of the Giessen school and his pupils, to enable us to draw some deductions which, although not extensive enough to be admitted as absolutely true, are nevertheless worth attention, as suggestive of much information, which each day's labour now promises to extend.

34. On food being taken into the stomach, it undergoes certain changes by which such of its constituents as are capable of forming albumen, as the protein elements of all animal and vegetable ingesta, are separated unchanged, and portions of its saccharine and amylaceous elements are converted into fatty or oily matters. This act constitutes the *first stage* of what was aptly termed by Dr. Prout[1] *primary assimilation*. The elements of food thus separated or re-arranged by this process, being absorbed by the lacteals, reach the right side of the heart, and after exposure to the influence of the air in the lungs, become converted into blood. This act constitutes the *second stage* of primary assimilation. From the blood all the tissues of the body are formed, and the

waste of the animal structures supplied; a process forming the *first stage of secondary assimilation*. The old and exhausted material has then to be removed, to make room for the deposition of new matter by a process referred to the *second or destructive stage* of the secondary assimilation of Dr. Prout, the metamorphosis of tissue of Professor Liebig.[2]

Dr. Prout expressed an opinion, that the elements of the albuminous tissues of the body are, during the process of metamorphosis, so arranged as to be converted into uric acid, or urates, and the atoms not entering into the composition of these bodies are so combined as to form "certain ill-defined principles."[3] The ulterior changes which the gelatinous tissues undergo in the act of destructive or metamorphic assimilation, were supposed by this distinguished physician to be intimately connected with their conversion into urea, and some saccharine principle, or its close ally, lactic acid. These opinions do not admit of positive proof, and hence can only be regarded as probable suggestions.

35. Baron Liebig has, in following the track thus first pointed out by our late illustrious countryman, endeavoured to follow with considerable minuteness, and to express in numbers the changes occurring during the process of destructive assimilation. He has assumed that the ultimate composition of animal flesh, as of muscle, and of blood, can be expressed by the same formula, and are consequently chemically identical. When, therefore, animal fibre is taken into the stomach, it, in a state of imperfect solution, reaches the circulation, possessing nearly the same chemical composition as the blood with which it becomes mixed. It then undergoes certain changes in the lungs, assuming (in the opinion of many physiologists) a more highly vitalised condition connected

essentially with the conversion of its albumen into self-coagulating fibrin, bodies, however different in their physical and molecular arrangement, nearly identical in composition. Recently, however, this view has been combated, and the fibrin has been suggested to be really a result of the metamorphosis of albumen, and to be regarded only as an effete product. Reaching in their course the nutrient capillaries, the elements of the food are deposited in the substance of a tissue, as a muscle, whose waste they thus supply. Ere these new molecules can be deposited, room must be made for them by the removal of old matter, and then the following beautiful results of vital chemistry are supposed to come into play. The exhausted atoms of the muscle cannot re-enter the blood as fibres (31), but their elements must be re-arranged, so as to form soluble compounds capable of being absorbed into the circulation and be carried to other organs. They therefore undergo destructive assimilation or metamorphosis; water and oxygen are conveyed to the muscle, the former in the fluid of the blood, the latter in the red particles, and the result is the re-arrangement of elements, which, whilst it enables the old tissues to be removed with facility, furnishes the pabulum for other and important secretions.

36. The researches of Professor Mulder,[4] of Utrecht, on the presumed combinations of protein with oxygen, have thrown some light on a very obscure part of the act of metamorphosis of tissues, which constituted the least tenable part of Liebig's hypothesis: he having, as already stated, assumed that oxygen is conveyed to the capillaries in the arterial blood-corpuscles, combined with iron, as sesquioxide—which giving up part of its oxygen, reaches the venous blood as protoxide. This idea can be only regarded as an ingenuous assumption,

for which no proof is offered by its talented author. All the elements of our food capable of being organized into albuminous tissues, consist chiefly of a substance which, from the important functions it fulfils, is called protein, a compound of carbon, nitrogen, hydrogen, and oxygen, $C_{48,}$ $H_{36,}$ $N_{6,}$ $O_{14,}$ or $C_{40,}$ $H_{30,}$ $N_{5,}$ $O_{12,}$ according to the mode in which the formula is calculated from the per-centage composition, combined with varying proportions of sulphur and phosphorus. Professor Mulder believes that he has demonstrated the existence of two oxides of protein, a binoxide and tritoxide, both of which are formed in the animal economy, and constitute, when combined with fatty matter, the buffy coat of inflamed blood. He considers that the protein of the food reaching the right side of the heart, and then circulating through the lungs, combines with oxygen, forming oxy-protein (binoxide, tritoxide, or both). These compounds reach the nutrient capillaries, and all or part are decomposed; the oxygen being employed for the disorganization of worn-out tissue, the protein thus deoxidized being deposited to supply its place. If more protein is set free than is required for the growth of tissue it passes unchanged into the veins, to be again oxidized in the lungs. The tritoxide of protein being soluble in water, is better enabled to traverse the minutest capillaries than if it existed merely diffused through the fluid containing it.

37. These statements, however ingenious, must be regarded as purely hypothetical, for the very existence of protein as a distinct substance is by no means generally admitted, in consequence of the difficulty of obtaining it free from sulphur. Indeed, in consequence of this fact, Liebig has called in question the accuracy of Mulder's views, although by no one was the theory, when

first announced, more warmly espoused than by its present great opponent. Indeed, as is well known, he rested upon it most of the theoretical deductions in the earlier editions of his celebrated work. Its accuracy was confirmed under his own eye, in his own laboratory, and by his own pupils, and it was certainly hardly generous afterwards to throw upon Mulder the whole onus of having overlooked the existence of sulphur in the so-called protein. The credit of first noticing this, indeed, belongs to my talented colleague, Dr. Alfred Taylor. Professor Mulder has since then entered fully into this subject, and has shown that a protein free from sulphur can be obtained; indeed, Laskowski, one of the many zealous pupils of Liebig, has shown that this may be readily effected by dissolving coagulated white of egg in a solution of potass, and separating the sulphur by digesting it with hydrated trisnitrate of bismuth, before precipitating the protein by acetic acid. But even if this were not the case, if the sulphur could not be separated, the term might be most conveniently retained to express a definite quantity of carbon, hydrogen, nitrogen, and oxygen. The memory is thus aided, and by no means is a greater call made upon our credulity than is effected in demanding our adhesion to the existence of the majority of the so-called compound radicals.

The theory of organic radicals has been given up, and Lehmann and others have turned their attention to conjugated compounds, salt-like combinations, and the like. He states that the discoveries of the resolution (or cleavage) into other substances, of amygdalin (Liebig and Wöhler), asparagin, salicin, and populin (Piria), the discoveries of the ammonia-alkaloids (Wurtz), and their theoretical constitution (Hoffman and Kolbe), and, finally, the observation that many nitrogenous bodies, when variously decomposed, yield special volatile alkaloids

(Anderson, Rochleder, Wertheim, and others), give a certain support to the view that protein substances may have a constitution analogous to that of these complex bodies, and that there may be contained in them several proximate constituents conjugated together, or combined in the manner of salts.*

38. On Liebig's hypothesis, the elements of muscular tissue are carried into the circulation, combined with water and oxygen, the latter, by its union with the carbon of the effete tissue, is supposed to aid in preserving the temperature of the body. On reaching the glandular structure of the liver, 50 atoms of carbon, 1 of nitrogen,† 45 of hydrogen, and 10 of oxygen, with an unascertained but considerable proportion of sulphur, are supposed to be filtered off from the portal blood, in the form of bile, a secretion which has to play an important part in the animal economy, prior to its final elimination. The more highly nitrogenized portions of the metamorphosed tissues are separated by the kidneys from the blood conveyed to them by the renal arteries chiefly in the form of urea and uric acid, whilst the carbonic acid formed by the slow combustion of the carbon of the original atoms of muscle in the capillaries is exhaled from the surface of the skin or pulmonary membrane. In this mode, by a wonderful influence of vital chemistry, the exhausted fibre is ultimately expelled from the animal structure.

An analogous explanation to the above, may be applied to the destructive assimilation of all the other animal tissues.

* Lehmann, translation by Dr. Day, vol. iii, p. 474.

† According to Bidder and Schmidt the whole of the nitrogen is eliminated from the body through the kidneys. Bischoff, on the contrary, maintains that one third of the nitrogen escapes some other way, perhaps by the skin and lungs, as carbonate of ammonia.

39. The following example will afford a good illustration of the results flowing from these views. According to Becquerel's researches,[5] the average proportion of uric acid to urea excreted in 24 hours by a healthy adult amounts to 8·1 grains of the former, and 255 of the latter, being in the ratio of 1 atom of the acid to 82 atoms of urea. From the accurate experiments of Allen and Pepys, it appears that 18,612 grains of carbonic acid gas are exhaled by an adult man in 24 hours; a quantity, as compared with the uric acid and urea, equivalent to about 800 atoms of carbon and 1600 of oxygen.

The average proportions of the bile cannot be determined with satisfactory accuracy, but from the lowest assumed quantity secreted by a man in 24 hours, 9640 grains may be regarded as near the truth. As bile contains about 90 per cent. of water, the amount of solids secreted in the bile during 24 hours will amount to 964 grains. Dried human bile contains about 62 per cent. of carbon, and hence 964 grains may be represented by about 14 atoms of solid bile, according to the provisional formula suggested by Dr. Kemp.[6]

For the purpose of yielding these products, about 35 atoms of muscular tissue must be acted upon by at least 1788 atoms of oxygen. The heat evolved by this slow combustion aids in keeping up the temperature of the body; and the products of this oxidation of exhausted tissue will be—

14	atoms of	solid bile, excreted by the liver.
32	,,	urea } excreted by the kidneys.
1	,,	uric acid } excreted by the kidneys.
800	,,	carbonic acid, excreted chiefly by the lungs.
403	,,	water, diffused through all the excretions.

	Carbon.	Nitrogen.	Hydrogen.	Oxygen.
35 atoms of muscular tissue .	1680	210	1365	525
1788 „ oxygen . .	...	...	...	1788
	1680	210	1365	2313
14 atoms of solid matter of bile	700	14	630	140
82 „ urea . . .	164	164	328	164
1 „ uric acid . .	10	4	4	6
800 „ carbonic acid .	800	...	...	1600
403 „ water . . .	...	...	403	403
	1674	182	1365	2313
In excess . .	6	28	...	...
	1680	210	1365	2313

The 6 atoms of carbon and 28 of nitrogen here unaccounted for, are probably eliminated in combination with the constituents of water, forming some of the less defined elements of the excretion—as compounds of ammonia, fatty, colouring, and odorous principles, &c.

The sulphur and phosphorus existing in the blood and some of the secretions have not been here taken into consideration, as experiments are still wanting to show in what proportion they exist.

40. It is evident that the atoms of worn-out tissues on re-entering the blood are ultimately evolved from the body as well-recognised elements of the excretions. Recent researches have rendered it possible that these effete matters are not at once resolved into urea, uric acid, &c., but undergo a series of transition changes, some of which have been studied with much success. Thus, in the fluids obtained by macerating the tissues of the body in water, the following bodies have already been

detected: Creatine, creatinine, inosinic acid, inosite, lactic acid, hypoxanthine, besides certain ill-defined volatile acids.

All these bodies may be regarded as transition stages of the metamorphoses of worn-out elements of tissues with the constituents of the excretions. The following views of the relation borne by some of these bodies to each other are by no means uninteresting.

41. Creatine is a crystalline body first discovered in the juice of flesh by Chevreul, and more recently submitted to a most masterly examination by that illustrious chemist to whom we owe so much, Baron Liebig. This substance appears to be the most important product of the metamorphosis of muscular tissue under the influence of destructive assimilation. I feel little doubt of the correctness of the opinion announced by Heintz, who differs from Liebig, in regarding this body as absolutely excrementitious; indeed, the fact of the copious excretion of creatinine by the kidneys fully bears out this view. The relations borne by creatine to several other bodies are very interesting. Thus, if the protein elements of effete muscular tissue in a nascent state come in contact with water and ammonia, which are so frequently the result of the decomposition of animal matter, we should have the elements of creatine, with the evolution of 23 atoms of hydrogen, which probably by their union with oxygen help to keep up the temperature of the body; for—

	C	H	N	O
1 atom protein	40+	30+	5+	12
+18 „ water		18		18
+10 „ ammonia		30	10	
	40+	78+	15+	30
= 5 creatine	40+	55+	15+	30
		23		

Creatine may be traced to the decomposition of the gelatinous as well as albuminous tissues; for they, in the re-arrangement of their nascent atoms, are prone to form glycocoll, and this body requires but the elements of ammonia to form creatine; for—

	C H N O
2 atoms of glycocoll	8+ 8+2+6
+1 „ ammonia	3+1
=1 „ creatine	8+11+3+6

Creatine has at present been detected only in the juices of the muscular tissues, and hence may be regarded as the exclusive product of their decomposition, brain and nervous matter containing none.

Some of the creatine is removed by the kidneys unchanged; some is converted into an active base, creatinine. This may be prepared artificially by boiling creatine with hydrochloric acid, and differs only from that body in containing less water.

	C H N O
1 atom creatine	8+11+3+6
—4 „ water	4 4
= creatine	8+ 7+3+2

Creatine, boiled with alkalies, is resolved into urea and sarcosin.

	C H N O
1 atom creatine	8+11+3+6
—1 „ urea	2+ 4+2+2
=1 „ sarcosin	6+ 7+1+4

It is hence probable that the creatine* found in flesh

* Mr. Moore, reviewing the works of Bidder and Schmidt, states that creatine, creatinine, and uric acid cannot be regarded as intermediate steps in

is, after all, a sort of transition stage between the protein elements and urea; the latter body being formed from the creatine, and not directly from the elements of the tissue. We have, however, the sarcosin to account for; this body has not been found in the urine or other excretions, but as it differs from lactate of ammonia only in the absence of one atom of water, it is not impossible that its elements become thus arranged:

	C	H	N	O
1 atom sarcosin	6+	7+	1+	4
+1 „ water		1		1
= lactate of ammonia	6+	8+	1+	5

Lactic acid is, as has been long believed, an important constituent of the fluids of the animal economy. Professor Liebig,[144] once the opponent of this view, has since become its advocate.

It is further interesting to observe that creatine bears a simple relation to uric acid, and under the influence of oxygen, and by union with carbonic acid and ammonia, or their elements, may possibly form this acid.

	C	H	N	O
1 atom creatine	8+	11+	3 +	6
2 „ carbonic acid . . .	2+			4
1 „ ammonia		3+	1	
6 „ oxygen				6
	10+	14+	4+	16
— 10 atoms water		10 +		10
= 1 uric acid	10+	4+	4+	6

the formation of urea, as they themselves traverse the renal capillaries undecomposed. But before we fully admit this, we must consider whether their elements would not be more naturally present in the urine in the form of urea.

A peculiar acid—the inosinic—has been discovered by Liebig in the juices of flesh, and is in all probability a result of secondary changes; this has not been met with in the excretions, but its constituents are exactly equal to those of acetic acid, oxalic acid, and urea. It is therefore, in all probability, broken up into these bodies:

	C H N O
Acetic acid	4+3+ 3
Oxalic acid	4+ 6
Urea	2+4+2+ 2
Inosinic acid	10+7+2+11

42. It is pretty evident that some organs of the body tend to resolve their element into transition compounds peculiar, or nearly so, to themselves. From some late researches of Professor Scherer,[145] it appears that the spleen presents a marked peculiarity. Thus a decoction of this organ in water contains a peculiar body which evidently constitutes an early phase in the conversion of the spleen by metamorphosis, or destructive assimilation, into uric acid. This interesting body is deposited, mixed with uric acid from the juices of the spleen, and it bears so close a resemblance to xanthine or uric oxide, that Scherer has named it hypoxanthine.

	C H N O
1 atom hypoxanthine	5+2+2+1
+1 „ oxygen	1
=1 „ uric oxide	5+2+2+2
+1 „ oxygen	1
=1 „ uric acid	5+2+2+3

Inosite is a very recent addition to our knowledge, for which we are also indebted to Scherer.[146] It is a peculiar

sugar found in the infusion of muscular tissue, apparently incapable of undergoing vinous fermentation, and consists of C_{12}, H_{12}, O_{12}. This in all probability is a transition stage in the metamorphosis of fat previous to its ultimate conversion into carbonic acid and water.

43. All speculations of this kind, notwithstanding the seductive interest with which they are invested, must be regarded with extreme caution, and, as in every case in which we endeavour to explain vital phenomena by the physical or chemical laws governing dead matter, be admitted as only provisionally correct. Their minute, and even general details, being liable to partial or complete alteration on the detection of a comparatively slight error in the analysis, or even in some cases of a mere difference of opinion regarding an atomic weight. But they are by no means to be idly rejected, for they enable us to group together a series of facts which, without the hypothetical relation now assumed, would scarcely seem to bear much relation to each other. They, moreover, suggest new investigations, and cause the views thus educed to be submitted to further researches, and in thus endeavouring to determine their truth or falsehood, new facts become almost daily elicited.

44. It is an interesting circumstance that an hypothesis involving the fundamental argument on which the relation of the elements of food to those of the blood, so ably advocated by both Mulder and Liebig, are based, was propounded by Anaxagoras, the Ionic philosopher, five hundred years before the Christian era. We are best acquainted with his views from the criticisms of Lucretius, but who quotes them only to refute them.*

* I have revised these passages from the edition of 'Lucretius' by the late head master of Eton, Dr. Keate, to whose elegant scholarship it is a satisfaction, if it be not presumption, as an old pupil, to bear my humble testimony.

Præterea, quoniam cibus auget corpus, alitque;
Scire licet, nobis venas, et sanguen, et ossa,
Et nervos alienigenis ex partibus esse:
Sine cibos omneis commisto corpore dicent
Esse, et habere in se nervorum corpora parva,
Ossaque, et omnino venas, parteisque cruoris;
Fiet, uti cibus omnis, et aridus, et liquor ipse,
Ex alienigenis rebus constare putetur,
Ossibus, et nervis, venisque, et sanguine misto.

Lucretius, de Rerum Naturâ, i, 859—868.

In his ignorance of the ultimate chemical composition of bodies, Anaxagoras* based his argument on their minute physical constitution, and hence he assumed that wheat really contained the elements of the blood and tissues ready formed, requiring only atomic aggregation in the living organism to convert them into blood and flesh. Lucretius triumphantly inquires why, if this be true, drops of blood are not visible on submitting wheat to the pressure of the mill-stones?—

Conveniebat enim frugeis quoque sæpe minutas,
Robore quom saxi franguntur, mittere signum
Sanguinis, aut aliûm, nostro quæ corpore aluntur:
Cum lapidi lapidem terimus, manare cruorem.

Ib., 880.

45. The physiological relations borne by the urine to other secretions both in regard to quantity and quality, are exceedingly interesting. The fact of this fluid constituting the stream by which a host of noxious ingredients either formed within the body or derived from without, is washed away, has been already alluded to (30). But there is another very important office which it performs in common with other secretions, depending upon the power possessed by the kidneys, of temporarily

* His doctrine was called Ὁμοιομέρεια.

compensating for the deficient action of other secreting organs. Thus, so long as the function of the skin and the kidney bear a normal relation to each other, all goes on as in health, a limpid secretion from the one and insensible exudation from the other announce that a just balance obtains between the two functions. But if the energy of the cutaneous function be increased so that more than a normal amount of fluid escapes from the skin, the kidneys compensate for this great loss by secreting a smaller quantity of fluid, so that the urine becomes concentrated, and its specific gravity is increased; and conversely, the bulk of the urine is often greatly increased when the skin is imperspirable. In this way the balance is for a time preserved, and no greater amount of fluid is drawn from the body than is consistent with health. Again, if the function of the liver be impaired, either from mechanical or other causes, highly carbonized products are eliminated in the urine (186), the kidneys performing temporarily the function of separating some or all of the elements of bile from the blood, as every case of jaundice teaches us. In these and other analogous modes the quantity and quality of the urine may become so modified as to lead to serious errors; and to induce a suspicion of the presence of renal disease, when, so far from any existing, the kidneys are really performing their most exalted function of depurating the blood of a noxious, and often even toxic agent. The fact of an excessive or diminished secretion of urine existing in any particular case cannot *per se* be regarded as indicative of disease of the kidney, any more than the excessive sweating so frequent in rheumatism or phthisis, or the diminished perspiration in fever, can be regarded as evidence of the existence of disease of the skin. Indeed, it is most important not to lose sight of the fact, that the presence

of abnormal constituents in the urine, or of healthy constituents in abnormal proportions, by no means indicates the necessary existence of renal disease. In the great majority of cases they really indicate the contrary condition, and rather, as already stated, point out that the kidneys are performing their functions in a manner more conducive to the health of the patient, by drawing off from the blood matter which, if not thus eliminated, would induce disease.

Physical characters of Urine.

46. In the investigation of urine in connection with diagnosis, it is important to notice its physical properties, especially its *density* or *specific gravity*, *colour*, *consistence*, and in some particular cases its optical properties.

Almost every one is familiar with the modes of discovering the density of the urine. This may be most readily accomplished by pouring some of the fluid into a cylindrical vessel, and immersing in it the little instrument known as the hydrometer, gravimeter, or urinometer (fig. 14). This is generally made of glass or metal, and consists of two bulbs (*a b*) and a narrow stem (*e f*). The instrument is made sufficiently heavy to cause it to sink to *e*, when placed in distilled water. Then, as all bodies immersed in fluids displace a bulk equal to themselves, it follows that in a fluid denser than water the instrument will not sink so deeply, and less of the stem will be immersed.[7] The space *e* to *f* is graduated into degrees corresponding to different densities. When such an instrument is allowed to float in a vessel of urine, the number on the stem corresponding to the level of

Fig. 14.

the fluid, will indicate very nearly its specific gravity. Thus if the degree 18 be on the surface of the urine, its specific gravity is said to be 1018 (the number 1000 being always added to the number on the stem). This shows that a vessel holding when quite full 1000 grains of distilled water, will contain just 1018 grains of the urine or other fluid under examination. These instruments are generally made of unnecessary magnitude. One of rather more than twice the size of the figure will float in a test-tube holding an ounce of urine, and is the most convenient for carriage and ordinary use.

47. It is obvious that for the indications of the gravimeter or urinometer to be correct, the scale on the stem must not be divided into equal parts, as the density of each stratum of fluid in which the instrument is immersed of necessity increases with the depth from the surface. A mathematical calculation is thus rendered necessary to compensate for the error thus existing in the indications on the stem. We are indebted to Mr. Ackland for the contrivance of a most ingenious machine for effecting the graduation of the scales of all these instruments, so as to remove this source of error very completely.* He has also ascertained that with glass urinometers, in which the weight of the bulbs, when loaded with mercury and fit for use, varies from 90 to 105 grains, the indications are very nearly correct, even when the temperature of the urine ranges from 60° to 80°, as the dilatation of the glass by the increased temperature nearly compensates for the necessarily diminished density of the fluid. Mr. Ackland has calculated the following table, by which, within a moderate

* Instruments thus graduated may be procured at Messrs. Horne and Thornthwaite's, 123, Newgate Street.

range of specific gravity, even this small error may be compensated:

A Table for reducing the indications of a Glass *Urinometer to the standard temperature* (60° *Fahr.*) *when the specific gravity has been taken at a higher temperature.*

Temp.	No. to be added to the indication.	Temp.	No. to be added to the indication.	Temp.	No. to be added to the indication.
60	·00	69	·80	78	1·70
61	·08	70	·90	79	1·80
62	·16	71	1·00	80	1·90
63	·24	72	1·10	81	2·00
64	·32	73	1·20	82	2·10
65	·40	74	1·30	83	2·20
66	·50	75	1·40	84	2·30
67	·60	76	1·50	85	2·40
68	·70	77	1·60		

Example.—Suppose the urinometer to float in urine of 73° temp. at 21. On referring to the table opposite 73° will be found 1·20, which is to be added to the indication 21, making the true specific gravity$=21\cdot+1\cdot2+1000$ $=1022\cdot2$.

48. If a urinometer be not at hand, any small and thin stoppered phial may be substituted. For this purpose counterpoise the empty bottle and stopper in a tolerably good balance, with shot or sand. Then fill it with distilled water, insert the stopper, and carefully ascertain the weight of the water it contains. Empty the bottle, fill it with urine, and again weigh it; the specific gravity of the fluid will be readily found by merely dividing the weight of the urine by that of the water.

As an example, if the carefully counterpoised phial

hold 478 grains of distilled water and 498 of urine, the specific gravity of the latter will be 1·0418, for $\frac{498}{478}=1·0418$. This process affords much more accurate results than can be obtained by the urinometer or gravimeter just described. Still, as the errors necessarily involved in the indications of the latter are not sufficient to be of any great practical importance, this instrument is generally preferred on account of the very great facility attending its use.

49. Much difference of opinion has existed regarding the average density of healthy urine (52), a discrepancy admitting of ready explanation by a reference to the state of health of the individual by whom it was secreted, the period of the day at which it was passed, the bulk of the fluid drunk in the course of the day, and the character of the previous ingesta.

Nothing can be more absurd than attempting to determine the average state of the density of the urine by the examination of specimens voided at different periods of the day. So seriously is the state of this secretion affected by comparatively slight causes, that from a neglect of this caution, a patient told only to "bring his water," might be supposed one day, from its density to be suffering from diabetes, and on the following he may surprise his medical attendant by presenting him with a specimen as light as spring water (51). In all cases where any approach to accuracy is required, an average sample from the urine passed in 24 hours into the same vessel must be selected: as this is, however, not always practicable, it is better to request the patient to furnish specimens of the urine passed immediately before going to bed (urina chyli), and of that voided on rising in the morning (urina sanguinis). The average density of these two specimens will give a near approach to the truth.

50. The law of the density of the morning urine being less than that passed at night holds good in disease, certainly in the majority of cases. A remarkable exception, however, occurs in some neuralgic and hysterical affections, in which, immediately after a paroxysm of the disease, the urine falls to its minimum of density at whatever period of the day it is secreted, often after an hysteric fit being scarcely heavier than pure water. The following table shows the results of some observations on the respective densities of night and morning urine in different diseases:

Density of urine passed at		Disease.
Night. Urina chyli.	Morning. Urina sanguinis.	
1·027	1·022	Irritable bladder.
1·026	1·022	Hæmoptysis.
1·026	1·020	Dyspepsia.
1·024	1·024	"
1·024	1·014	"
1·022	1·016	Phthisis.
1·021	1·019	Oxaluria.
1·005	1·015	Hysteria.
1·020	1·018	Healthy.

A very curious statement has been made in Germany by Dr. Schweig,[11] that the density of urine presents a constant rate of increase and decrease during the day, and that *cæteris paribus* it ranges from 1·017 to 1·022 in the forenoon, 1·023 to 1·028 in the afternoon, 1·019 to 1·028 in the evening, and 1·012 to 1·025 during the night. Taking the night urine alone he states its density to vary through certain limits in a cycle of six days, so that twice in this period its density attains a "high minimum;" on the third and fourth night being

higher than on the fifth and second, but then being lower than on the first. Five of these cycles occur, according to Dr. Schweig, in each lunar revolution, counting the night before the new moon as the second day of one of his cycles. The following is the density of night urine taken from an average of 20 such periods:

Nights of the Cycle.	*Density of the Urine.*
1	1·022
2	1·017
3	1·019
4	1·020
5	1·019
6	1·017

I have not been able to verify these statements, and am inclined to believe that these supposed cycles of daily variation bear a direct relation to the periodicity of the meals (71).

51. It is quite impossible to assign any limits within which the specific gravity of the urine secreted at different periods of the twenty-four hours may possibly range. In addition to the bulk of water eliminated from the circulation by the kidneys in a given time being materially affected by the state of surface (45) and other causes, the amount of fluids drunk will exert an important effect in modifying the density and bulk of the urine. In many persons mere mental anxiety, or the ingestion of a few cups of tea, a glass or two of hock, or a goblet of soda-water, will at once determine the secretion of urine of a density as low as 1·002 or 1·003. The free use of aqueous diluents will also greatly increase the bulk, and in a corresponding degree diminish the density of the urine. And from some recent observa-

tions of Professor Liebig it appears probable that the purer the water, the more freely is it absorbed into the blood, and eliminated by the kidneys, the presence of small quantities of saline matter considerably retarding its absorption and subsequent excretion (385).

It was observed by Becquerel[13] that a man whose normal average of urine in 24 hours was 30 ounces, passed 56 ounces after swallowing about a quart of water in the day. In another case the natural average, or 32 ounces, was raised to 87 ounces after the imbibition of half a gallon of water in the 24 hours.

Severe mental emotion, especially a paroxysm of hysteria, will also determine the secretion of pale aqueous urine, of low density (50). A young woman who naturally passed in 24 hours about 35 ounces of urine, voided 86 ounces after the occurrence of a hysteric fit in the course of the day.

52. Dr. Prout's experience led him to assign 1·020 as the average gravity of healthy urine, and this completely agrees with my own observations. From a number of careful observations made by Becquerel, it appears that the mean density of all the urine passed in 24 hours, and examined by him, was in men 1·0189, and in women 1·0151, the mean in the two sexes being 1·017. Dr. Routh[146] has made a very careful and valuable series of researches on the subject, and from an average of eighteen cases he has shown that 1·021 very nearly represents the specific gravity of the urine secreted in 24 hours.

53. The average quantity of urine secreted in 24 hours in this country varies from 30 to 40 ounces; this is Dr. Prout's estimate, and is certainly the most correct. Dr. Routh found in eighteen cases the average quantity did not exceed 35 ounces. It is, however, capable of varying from at least 20 to 50 ounces with-

out exceeding the possible limits of health, the quantity excreted in summer being as a general rule less than during winter, on account of the greater activity of the functions of the skin in warm weather.

M. Becquerel regards 43 ounces in men and 47 in women as the most accurate expression of the average quantity of urine. The habitual use of weak subacid wines in France will from their diuretic influence sufficiently explain the discrepancy existing between the remarks of English observers and those of Becquerel.

54. Presuming that in any given class of affections the several ingredients existing in the urine preserve nearly their normal ratio, it is obvious that if, by any means we could appreciate with tolerable accuracy the quantity of solids or "real urine" excreted in a certain time, we should be able to learn, not only to what extent the kidneys are performing their great and important function of depuration, but should also obtain data by which it would be possible to measure, within certain limits, not only the amount of nourishment acquired from ingesta, but of the rapidity of the destruction of the effete tissues of the body under the influence of the oxygen of the arterial blood (35). In this manner we may recognise the existence of a series of causes influencing the condition of our patients, the detection of which would otherwise have been scarcely possible. It is also possible that we may occasionally obtain some aid in the diagnosis of the localization of the diseased action in the kidneys where those organs are structurally affected; for the researches of Professor Bowman have shown, that the separation of the water from the blood takes place through the Malpighian tufts, whilst the saline and other characteristic elements of the urine are separated in the tubes by means of epithelial structure.

Indeed, epithelial cells have been discovered in urinary deposits actually distended with crystals of uric acid and of oxalate of lime.[147]

The first element in an inquiry of this kind will be, to obtain a tolerably accurate measure of the quantity of urine secreted in twenty-four hours. Simple as this appears, it in practice is attended with no small difficulty. Not only is it no easy matter to make our patients quite understand what we require, but the loss of urine generally voided during the action of the bowels will frequently prove no small obstacle to our learning the exact quantity secreted. The patient should be told to pass water at noon, and rejecting the portion then excreted, to collect all that he passes up to the same hour the next day, when he should take care to empty his bladder completely.

Having thus measured the amount of urine secreted in a given period, we are yet far from having any satisfactory information as to the proportion of work done by the kidneys in that time, as far as their depurating functions are concerned. The amount of fluid in the renal secretions being liable to serious variations, according to the quantity of fluids drunk, the action of the skin, &c. Thus, a person may, under peculiar circumstances, void, in twenty-four hours, forty ounces of urine, and on the next day but twenty, and yet the amount of depurating duty performed by the kidneys be the same; for the former bulk of urine, if of a density of 1·015, will contain about as much solid matter as half that quantity if of a specific gravity of 1·030.

55. The amount of solid matters existing in the urine can, of course, be discovered by the evaporation of a given quantity to as dry an extract as can be obtained. The practical difficulties attending this process are familiar to

every one who has ever performed the task; and, moreover, the time required for its performance would preclude its being had recourse to sufficiently frequently to be of any real service.

It has, therefore, been proposed to calculate the quantity of solid matter present in the urine from its specific gravity; and for this purpose the following different formulæ have been suggested by the late Dr. Henry, Dr. E. Becquerel,[8] and Dr. Christison.[9] If D = the density or specific gravity of the urine, and Δ = the difference between 1000 and its density—

The quantity of solids in 1000 grs. is, according to	Dr. Henry,	$\Delta \times 2{\cdot}58$
" "	Dr. Christison,	$\Delta \times 2{\cdot}33$
" "	Dr. Becquerel,	$\Delta \times 1{\cdot}65$

It is true that by formulæ of this kind *only an approximation to the truth* can be gained, in consequence not only of the different densities of the various elements of the urine, but from their not always existing in the same proportion, and therefore are never to be relied on, where great accuracy is required, as in the chemical analysis of the urine. Yet they are of great value in the investigation of disease at the bedside, as affording an approach to a knowledge of the solids removed from the system in a given time, sufficiently accurate for all clinical purposes, either in relation to diagnosis, or indications of treatment. Of these three formulæ, that of Dr. Christison has been shown by the researches of Dr. Day[10] to be the most exact, and to afford results generally sufficiently accurate for the guidance of the practitioner.*

* In addition to these we may mention Trapp's formula, the error of which, according to Vogel, cannot exceed one tenth in healthy, and one fifth in morbid urine. If Δ represents the excess of the specific gravity of urine

56. The following table, calculated from Dr. Christison's formula, shows at a glance the quantity of solids and fluid existing in 1000 grains of urine of different densities :

TABLE 1.

Specific gravity.	Solids.	Water.	Specific gravity.	Solids.	Water.
1001	2·33	697·67	1021	48·93	951·07
1002	4·66	995·34	1022	51·26	948·74
1003	6·99	993·01	1023	53·59	946·41
1004	9·32	990·68	1024	55·92	944·18
1005	11·65	988·35	1025	58·25	941·75
1006	13·98	986·02	1026	60·58	939·42
1007	16·31	983·69	1027	62·91	937·09
1008	18·64	981·36	1028	65·24	934·76
1009	20·97	979·03	1029	67·57	932·43
1010	23·30	976·70	1030	69·90	930·10
1011	25·63	974·37	1031	72·23	927·77
1012	27·96	972·04	1032	74·56	925·44
1013	30·29	969·71	1033	76·89	923·11
1014	32·62	967·38	1034	79·22	920·78
1015	34·95	965·05	1035	81·55	918·45
1016	37·23	962·72	1036	83·88	916·12
1017	39·61	960·39	1037	86·21	913·79
1018	41·94	958·06	1038	88·54	911·46
1019	44·27	955·73	1039	93·87	909·13
1020	46·60	953·40	1040	93·20	906·80

The mode of using this table is exceedingly simple; for having discovered the density of the urine passed in 24 hours by means of the gravimeter or specific-gravity bottle, a single glance at the table will be sufficient to show the proportion of solid matter and water in 1000 grains of the urine. Then, by weighing the whole quantity of urine passed in 24 hours, the weight of solids secreted by the kidneys may be calculated by a simple rule of proportion.

above that of water (= 1000), the amount of the solid constituents of 1000 parts of that fluid will be represented by 2 Δ.

57. As it is much easier to obtain the measure than the weight of urine passed in a given time, the following table becomes of use in enabling us to calculate the weight of the urine (in grains) from its bulk. A pint of distilled water weighing 8750 grains.

TABLE 2.

Specific gravity.	Weight of one pint.	Specific gravity.	Weight of one pint.
	Grains.		Grains.
1·010	8837	1·023	8951
1·011	8846	1·024	8960
1·012	8855	1·025	8968
1·013	8863	1·026	8977
1·014	8872	1·027	8986
1·015	8881	1·028	8995
1·016	8890	1·029	9003
1·017	8898	1·030	9012
1·018	8907	1·031	9021
1·019	8916	1·032	9030
1·020	8925	1·033	9038
1·021	8933	1·034	9047
1·022	8942	1·035	9056

58. The following example will be sufficient to point out the mode of using the preceding tables.

Ex.: A patient passes in 24 hours $2\frac{1}{2}$ pints of urine of the specific gravity 1·020, what is the weight of solid matter thus excreted by the kidneys?

1000 grains of urine, specific gravity 1·020, hold dissolved 46·6 grains of solids (Table 1), and a pint will weigh 8925 grains (Table 2); then,

$$\frac{8925 \times 46{\cdot}6}{1000} = 415{\cdot}9 \text{ grains of solids in a pint;}$$

and $415{\cdot}9 \times 2\frac{1}{2} = 1039{\cdot}72$ grains, being the total quantity present in urine of 24 hours.

59. Subsequent to the publication of the first edition

of this work, I calculated another table from Dr. Christison's formula ($\Delta \times 2{\cdot}33$), which is exceedingly convenient from its showing at a glance the number of grains of solids in, and the weight of, a fluid ounce of urine, of every density from 1·010 to 1·040.

TABLE 3.

Specific gravity.	Weight of one fluid oz.	Solids in one fluid oz.	Specific gravity.	Weight of one fluid oz.	Solids in one fluid oz.
		Grains.			Grains.
1010	441·8	10·283	1025	448·4	26·119
1011	442·3	11·336	1026	448·8	27·188
1012	442·7	12·377	1027	449·3	28·265
1013	443·1	13·421	1028	449·7	29·338
1014	443·6	14·470	1029	450·1	30·413
1015	444·0	15·517	1030	450·6	31·496
1016	444·5	16·570	1031	451·0	32·575
1017	444·9	17·622	1032	451·5	33·663
1018	445·3	18·671	1033	451·9	35·746
1019	445·8	19·735	1034	452·3	36·831
1020	446·2	20·792	1035	452·8	37·925
1021	446·6	21·852	1036	453·2	38·014
1022	447·1	22·918	1037	453·6	39·104
1023	447·5	23·981	1038	454·1	40·206
1024	448·0	24·051	1039	454·5	41·300

A glance at these figures presents us with a mode of recollecting the quantity of solids existing in urine of different specific gravities depending upon the curious coincidence existing between the figures expressing the densities and the weight of solids present; and is exceedingly useful when the table is not at hand for reference. Thus, if the specific gravity of any specimen of urine be expressed in four figures, the two last will indicate the quantity of solids in a fluid ounce of the urine, within an error of little more than a grain, when the density does not exceed 1·030; above that number the error is a little greater. To illustrate this, let us suppose we are called to a patient,

the integrity of the depurating functions of whose kidneys we are anxious to learn. The quantity of the urine excreted in 24 hours amounts, we will suppose, to three pints or sixty ounces, and the density of the mixed specimens passed in the time alluded to is 1·020; now we merely have to multiply the number of ounces of urine by the last two figures of the specific gravity, to learn the quantity of solids excreted; or $60 \times 20 = 1200$ grains of solids. If the table were at hand, the calculation would be more rigid, for we should multiply 60 by 20·79, instead of 20; the product, 1247 grains, shows that by the former mode an error of 47 grains has been committed; an amount not sufficient to interfere materially with drawing our inductions by the bedside, and of course capable of immediate correction by referring to the table at our leisure.

60. From a large number of observations, it appears that the average amount of work performed by the kidneys in the adult, may be regarded as affecting the excretion of from 600 to 700 grains of solids in twenty-four hours. Although certain peculiarities connected with muscular exercise, regimen, and diet, as well as certain idiosyncracies of the patient, may influence this, yet if we regard 650 as the average expression of the number of grains of effete matter separated in twenty-four hours by the kidneys, we shall not commit any very serious error. In calculations of this kind much latitude must be allowed, and it ought at least to be assumed that the kidneys may excrete fifty grains more or less than the assumed average, without exceeding or falling short of their proper duty.

Recent and very extended researches have convinced me, that the indications afforded by the characters of the quantity of solid elements of the urine excreted by the kidneys in a given time, are of the highest importance, not only as an exponent of functional lesion, but as a

most important guide to the treatment of diseases. These views I developed at some length in my lectures at the Royal College of Physicians in the spring of 1848, and I hope to revert to them in the concluding chapter of this volume.*

61. Among the physical characters of urine, the tints not unfrequently present in different maladies are of great importance, and worthy of being carefully studied. Whatever may be the nature of the colouring ingredients of healthy urine, it is pretty evident that they are capable of generating but a small series of tints; varying according to the degree of dilution from nearly colourless to the usual pale amber colour, and up to deep brown. When much diluted, urine presents a faint greenish tint, as in the urine of early infancy, and in that of chlorosis and hysteria. If bile or blood be present, a variety of colours, varying from red to brown, blackish-green or apple-green, are produced, the latter hue being occasionally indicative of the presence of cystine (191). It is often of great importance to distinguish between the substances causing some of the various colours passed by the urine, for which purpose the following table will be found of use:

* Dr. Bence Jones is of decided opinion that no reliance can be placed on any other mode of obtaining the amount of solids in the urine than by careful weighing; and there is no doubt that he is correct where strict accuracy is required, as appears from the following experiments: about 500 grains of urine were in each case evaporated:

	Specific gravity.	*Solid residue.*	*Per 1000 grs. of urine.*
Before dinner .	1028·0	found 67·03 grains;	by table 65·2 grains.
After dinner .	1028·5	„ 65·59 „	„ 58·5 „
Before dinner .	1028·2	„ 64·77 „	„ 65·0 „
After dinner .	1034·3	„ 84·65 „	„ 79·0 „
Before dinner .	1024·7	„ 60·77 „	„ 58·0 „
After dinner .	1024·8	„ 64·61 „	„ 58·0 „
Before dinner .	1024·8	„ 56·67 „	„ 58·0 „

Colour.	Cause of colour.	Chemical and physical characters.	Pathological indications.
Red. (A)	Purpurine.	Nitric acid produces a deposit of uric acid almost immediately. No change by heat. Alcohol digested on on the extract, acquires a fine crimson colour. Density moderate.	Portal congestion; it is generally connected with organic mischief of the liver or spleen.
(B.)	Blood.	Becomes turbid by heat and nitric acid, its colour changing to brown. The microscope discovers floating blood discs.	Hemorrhage in some part of the urinary passages.
Brown. (C.)	Concentration.	Nitric acid precipitates uric acid readily. Density high, the addition of hydrochloric acid to some of the urine previously warmed, produces a crimson colour.	Fever.
(D.)	Blood.	See B; coagulation by heat, and nitric acid less marked.	Obstruction to the escape of bile from the liver or gall-bladder; and the presence of some or all of the elements of bile in the circulation.
(E.)	Bile.	A drop of nitric acid, allowed to fall in the centre of a thin layer of urine on a white plate, produces a transient play of colours, in which green and pink predominate.	
Greenish-brown. (F.)	Blood.	See B; occurring in alkaline urine.	
(G.)	Bile.	See E; occurring in very acid urine.	
Grass-green. (H.)	Excess of sulphur.	Unchanged by heat or nitric acid.	Presence of cystine.

Vogel arranges the scale of colours in the three following groups:

1st. Yellowish urines.

1. Pale yellow, like a weak solution of gamboge.
2. Bright yellow, like a medium solution of gamboge.
3. Yellow, like a strong solution of gamboge.

2d. Reddish urines.

1. Reddish-yellow, like gamboge with a little carmine.
2. Yellowish-red, like gamboge with more carmine.
3. Red, like carmine with a little gamboge.

3d. Brown urines.

1. Brownish-red.
2. Reddish-brown.
3. Brownish-black (162).

62. It must not be forgotten that the colouring matter of many drugs when taken into the stomach readily and rapidly enter the urine, and from the peculiar appearance presented by it might lead to an unfounded suspicion of its being indicative of many urinary diseases. The colouring matters of the chimaphyla, hæmatoxylum, indigo, senna, and rhubarb, will thus tint the urine very deeply, the latter more especially. I have often seen urine, coloured by rhubarb, mistaken for bilious urine. The error can be at once discovered by the addition of liquor ammoniæ, which converts the dark orange into a crimson colour.

63. Urine occasionally varies in *consistence*, and instead of being fluid, as is generally the case, acquires a con-

siderable amount of viscidity. This is sometimes only to be detected by the readiness with which it froths on agitation, and the length of time the bubbles are retained, as in diabetes mellitus. In other cases the urine may be so viscid as to allow of being drawn into threads from the presence of mucus (331), although the latter generally forms a dense layer at the bottom of the vessel. The same thing happens if pus occurs in rather concentrated or alkaline urine, as the alkali or saline matters present re-act upon the albuminous constituents of the pus, and convert it into a mucus magma, as pointed out by Dr. Babington and myself[14] (328).

It is occasionally, though rarely, observed that the urine is fluid whilst warm, but becomes semi-solid, like a mass of jelly, on cooling. This change depends upon the presence of self-coagulating albumen or fibrin, a state of things generally connected with severe organic mischief in the kidneys, although in some instances dependent only upon mere functional disturbance.

In the former editions of this work I stated that in a few rare instances, occurring chiefly in urine loaded with oxalate of lime, I had found it quite fluid whilst cold and gelatinizing when heated, retaining, however, its transparency. This curious change being best observed when water is poured on the warm urine, when the gelatinous mass floats for some seconds in the water before it completely dissolves. Recent observations have led me to trace the cause of this to an abundant deposit of urate of ammonia, accompanying the oxalate, dissolving by the heat employed, and soon after separating as a gelatinous hydrate.

64. The optical properties of the urine have scarcely been applied to diagnosis, with the exception of the action saccharine urine exerts on polarized light, which

has been proposed by M. Biot,[15] and applied by M. Bouchardat[16] to the detection of diabetes mellitus. It is quite out of place to notice here the theoretical action of diabetic urine on polarized light; for an account of which I would refer the reader to works especially devoted to the investigation of physical phenomena:[17] and now simply content myself with pointing out the readiest mode of applying this property to diagnosis.

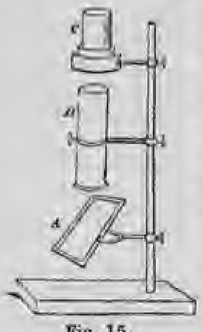

Fig. 15.

Let a mirror (A), composed of half a dozen pieces of thin window glass, be fixed to an arm of a common retort-stand. A brass tube (B), open at top, and closed below with a plate of glass, is fixed to a second arm. This tube should be an inch in diameter, and six or eight inches long. In a third arm, at (C), is fixed a ring of wood, supporting a doubly refracting rhomb of calcareous spar. Let the tube (B) be filled with water, and allow the light of a candle, or of the clouds, to be incident on the mirror (A) at an angle of 56° 45. A ray of light, polarized in a vertical plane, will consequently be reflected through the column of water in B. Then look through the crystal (C) and two images of the bottom of the tube (B) will be visible. These images are colourless, and differ merely in the intensities of their illumination. Slowly revolve the crystal (C) and one of the images will cease to be visible four times in an entire revolution. Having thus become familiar with the management of the instrument, empty the tube (B) and fill it with very clear syrup. Again revolve the eye-piece (C), and now, instead of two uncoloured images only being visible, two, tinted with the most vivid colours

of the spectrum, will be seen. These will change their hues by revolving the crystal (C). These beautiful tints are generated by a physical change produced by the solution of sugar on the transmitted plane-polarized light, giving rise to the phenomena of circular polarization.

65. The quantity of sugar existing in the urine is never sufficient to present the beautiful phenomena in a satisfactory manner without taking very many precautions to ensure success. For this purpose the tube (B) should be changed for one 14 inches long, as the quantity of sugar in urine is so much smaller than in syrup, that a larger column of fluid becomes necessary to develope the optical phenomena above described. As one effect of this is to oppose a greater obstacle to the passage of light, a more vivid beam becomes necessary. To attain this, a good light should be thrown into the tube from a concave mirror, which should be substituted for the reflecting plates (A) in the figure. This light should be polarized by allowing it to traverse a Nicol's single-image prism, screwed into the lower end of the tube holding the urine.

If then diabetic urine, carefully filtered to render it as clear as possible, be placed in the tube, the utmost care being taken to exclude all extraneous light, the coloured images will be visible, not, however, with the vivid tints presented by the syrup, as their hues will be modified by the colour of the urine and quantity of sugar present. *Whenever in this apparatus two images possessing different colours, however faint, are seen simultaneously, it is certain that the fluid in the tube possesses the power of circular polarization.* And, as in the case of urine, but two bodies have been found which produce this physical change in light, viz., sugar and albumen, it is easy to discover the nature of the substance which communicates

this property to the urine. If, therefore, a specimen of urine, which does not coagulate by heat, produces the coloured images when examined in the polariscope, it is certain that sugar is present.

If the urine be tolerably free from colour, as is often the case in diabetes, mere filtration through bibulous paper will render it sufficiently transparent to exhibit these phenomena. But, if deeper coloured, a small quantity of the solution of di-acetate of lead should be added, and the mixture briskly agitated; in this way almost all the urinary pigment is precipitated, and on passing the fluid through a filter it becomes fitted for the polariscope.

66. The comparative increase or decrease in the quantity of sugar in the urine during the progress of treatment may be detected by observing the extent of the arc through which it is necessary to rotate the eye-piece before any particular tint reappears or disappears. The best and most constant tint to assume as an index is a dark bluish-violet colour, which precedes a yellowish red and follows a deep blue, and has the advantage of being a distinct colour easily recognised. Let us suppose the tube of the apparatus is filled with diabetic urine, and by careful examination a rotation of the eye-piece through 9° is required to develope the dark violet colour. If on a subsequent examination a column of urine of the same length requires a rotation of 18° or 27° to develope the same colour, we learn that the quantity of sugar present is doubled or tripled in quantity, whilst if a rotation of $3\frac{1}{2}^\circ$ or 6° is sufficient, it shows that the sugar has fallen to one half or two thirds the quantity found on the first observation.

There are many serious practical difficulties in the application of the polarizing power of urine to the detec-

tion of sugar, which will probably ever prevent its being generally employed, but M. Bouchardat having drawn the attention of the profession to it, it was necessary to give some explanation of it. To obtain results at all approaching to accuracy, the beautiful polariscope, contrived by M. Soleil, of Paris, should be employed. Its manipulation requires, however, more tact than is likely to fall to the lot of any except those who have devoted some time to physical investigation, whilst its expense (£18 or £20) places it beyond the reach of many practitioners.

CHAPTER III.

CHEMICAL PHYSIOLOGY OF THE URINE.

67. Healthy urine, uninfluenced by food, is sufficiently acid to redden litmus paper, but the intensity of the action of urine on the test-paper is subject to remarkable variations, sometimes being even replaced for a short time by an alkaline reaction without involving the necessary presence of disease. Dr. B. Jones has carefully investigated this subject, and he has discovered that the urine is always most acid when the contents of the stomach possess the greatest acidity and *vice versâ*. The urine passed the longest after food is generally the most

acid, that passed during digestion is three or four time less acid, and even sometimes alkaline. Immediately before each meal, the urine always showed the greatest acidity; that passed in two or three hours after always showed the least. The decrease was greatest three hours after breakfast, and five or six hours after dinner, when it reached its minimum. In the absence of food, the acidity remained nearly the same for twelve hours, but fell directly after taking food. With animal food only, the diminution of acidity after food was very rapid and more permanent than after mixed diet; indeed, the urine often became alkaline. With vegetable food (excluding subacid fruits) the decrease of acidity after food was much less marked and the increase of acidity before food much more evident. Dr. B. Jones's[148] essay on the subject merits, and will well repay, a careful study.

68. The chemical composition of urine has been the subject of repeated investigations during the present century, and numerous statements have from time to time been made public, respecting the elements contained in this important fluid. In a physiological point of view, the urine of health may be regarded as naturally made up of the following classes of ingredients dissolved in water:

I. ORGANIC PRODUCTS.

1st. Ingredients characteristic of the secretion produced by the destructive assimilation of tissues, and separated from the blood by the kidneys.	Urea, uric acid, creatine, creatinine, colouring and odorous principles.
2d. Ingredients developed principally from the food during the process of assimilation.	In addition to the above, hippuric acid, lactic acid; accidental constituents.

II. INORGANIC PRODUCTS.

3d. Saline combinations, separated from the blood, and derived from the food.	Sulphates, phosphates, chloride of sodium, and all soluble salts taken with the food and often undergoing decomposition in the system.
4th. Saline combinations chiefly generated during the process of destructive assimilation.	Sulphates, Phosphates.

III. INGREDIENTS DERIVED FROM THE URINARY PASSAGES.

5th. Mucus of the bladder.
6th. Débris of epithelium.
7th. Phosphate of lime.

Of these, the first class of ingredients can alone be considered as really essential to the urine, and characteristic of it as a secretion, the kidneys being the only organs which normally eliminate these elements from the blood. The saline ingredients of the second class are met with in most secretions of the body, with the exception of the sulphates, which are rarely found except in the urine. The third class of elements is met with in all fluids passing over mucous surfaces, the phosphate of lime being derived from the mucus, of which it is a constituent.

69. As all unnecessarily minute chemical details of the analyses of urine are more interesting in their abstract bearings than in relation to physiology and pathology, it would be quite out of place to insert any of the very elaborate views which have been given by

some writers of the composition of the secretion under consideration. I prefer adopting the analyses of M. Becquerel,[18] as the most practically useful, especially as they are corroborated by the result of the researches of most recent and trustworthy observers. The following table presents a view of the normal average composition of the urine passed by healthy persons in the course of twenty-four hours; the weight of the constituents being expressed in grains:

	Urine of men.		Urine of women.		Means of both.	
	In 24 hours.	In 1000 grains.	In 24 hours.	In 1000 grains.	In 24 hours.	In 1000 grains.
Weight of urine	19516	1000	21124	1000	20320	1000
Specific gravity	1·0189		1·0151		1·01701	
Solids	610·	31·1	526·8	24·95	568·	28·
Urea	270·	12·8	240·	10·366	255·	12·
Uric acid	7·6	0·391	8·6	0·406	8·1	0·398
Fixed salts	150·	7·63	126·	6·14	138·	6·885
Organic matters and volatile saline combinations	176·	9·26	145·	8·	160·5	8·63

The organic matters mentioned in the above table consist of a mixture of creatine and creatinine with hippuric and, according to some, lactic acid; a colouring pigment rich in carbon, an extractive matter containing a considerable proportion of sulphur, with a salt of ammonia, and probably of some other bodies in smaller quantities, with whose nature we are yet unacquainted.

70. The fixed salts referred to in this table consist of combinations of chlorine, phosphoric, and sulphuric acid, with lime, soda, potassa, and magnesia, or their metallic bases: these substances exist normally in the following average proportions:

	In the urine of 24 hours.	*In 1000 grains.*
Chlorine	10·15 grains	0·502 grains.
Sulphuric acid	17·3 „	0·855 „
Phosphoric acid	6·4 „	0·317 „
Soda, Lime, Magnesia, Potassa	106·1 „	5·224 „
	139·95	6·898

The proportions in which these several ingredients exist in the urine are liable to great temporary variations from slight causes, depending upon the nature of the food, amount of exercise, and state of general health. The amount of solids in the secretion increases usually in a direct ratio with the amount of muscular exertion, and consequently metamorphosis of tissues, and inversely with the length of time elapsing after taking food.

71. The following example will be sufficient to point out the great variation existing in the composition of urine passed at different periods of the day. I collected carefully all the urine secreted by a person in good health during twenty-four hours: it amounted to only 22 ounces; he had previously drunk very little. It was passed at the following hours: at 8 a.m., eight ounces, depositing urates; at 1 and 5 p.m., six ounces altogether; at 11 p.m., eight ounces; all these specimens were acid.

The first of these was passed after having been ten hours without food, and consequently was a good specimen of *urina sanguinis*; the second was influenced by the morning meal and a slight lunch at noon; whilst the third, *urina cibi*, contained the products of the metamorphosis of food taken at dinner early in the evening. The

composition of these three specimens was, in 1000 grains, as follows:

When excreted.	A. 8 a.m.	B. 1 and 5 p.m.	C. 11 p.m.	D.	E.
Specific gravity	1·016	1·020	1·030	...	1·018
Water	962·72	953·40	930·10	...	958·
Solids	37·28	46·60	69·90	...	41·94
Urea	14·3	15·3	24·4	180·4	11·0
Uric acid	0·28	0·9	1·33	8·0	1·1
Fixed salts	5·1	16·5	9·9	98·0	11·2
Creatine, creatinine, colouring matter, and volatile saline compounds	17·6	13·9	34·27	213·0	18·6

The bulk of the urine secreted was nearly one half the average, being but 22 ounces, and the composition of the solids existing in the whole quantity is shown in the column D of the above table. In the following twenty hours, the same person having partaken more freely of fluids, secreted 36 fluid ounces of urine, and the composition of 1000 grains of which is shown in column E.

72. *Urea.*—Chem. comp. C_2, N_2, H_4, $O_2=60$. This very important substance constitutes the form under which a large quantity of nitrogen is expelled from the system; 270 grains of urea, or more than half an ounce, being on an average excreted by a healthy man in the course of twenty-four hours.

Urea, in consequence of its combining with acids like a weak base, can be very readily discovered in urine. The nitric or oxalic acid may be used for its detection; the former being the most convenient for clinical observations. For this purpose let about a drachm of urine be

placed in a watch-glass, and about half that quantity of colourless nitric acid be carefully added. If a normal proportion of urea exist, no change, except a darkening in tint, and the evolution of a few bubbles, will be observed, unless the weather be exceedingly cold, or the glass be placed in a freezing mixture, and then a delicate plumose crystallization of nitrate of urea will commence at the edge of the fluid. Urea may be obtained from the nitrate by pressing it between folds of blotting paper until it is nearly dry. The satin-like mass thus left, if dissolved in boiling water, and digested with a little animal charcoal, yields up most of its colouring matter, and by separation may be obtained in irregular rhomboidal plates. The nearly pure nitrate should be dissolved in as little water as possible, and carbonate of potass added until all effervescence ceases. In this way nitrate of potass is formed, and urea set free. The whole should be carefully evaporated to dryness, and digested in hot absolute alcohol, which readily dissolves the urea; and by evaporation it may be obtained in four-sided prisms, very soluble in both hot and cold water, and possessing the cool and saline taste of nitre.*

73. Under ordinary circumstances, no crystals of nitrate of urea will appear on the addition of nitric acid, unless the urine be concentrated by previous evaporation to one half its bulk, or even less, before adding the acid. In some cases, indeed, an excess of urea exists, and then a rapid formation of crystals of the nitrate occurs, occasionally so copiously that the mixture becomes nearly solid. It is important, whenever this is the case, to measure the bulk, and ascertain the specific gravity of the whole quantity of urine passed by the

* See Note, page 14, for the processes of obtaining and measuring urea recommended by Dr. Odling and Dr. Davy.

patient in twenty-four hours; for unless these exceed the average proportions of health, there is no proof that an actual excess of urea is excreted by the kidneys. A particular specimen of urine may appear richer in urea than natural, simply from the diminished amount of water present, as is well shown in the preceding table (71); in which, although the total quantity of urea present in the urine of twenty-four hours was much below the average, yet the proportion found in 1000 grains at three different periods of the day far exceeded it. On this account the urine secreted shortly after a full meal, especially of animal food, as well as that voided after excessive perspiration, generally crystallizes on the addition of nitric acid.

74. *Physiological origin of urea.*—This has been already traced to the destructive assimilation of the tissues of the body (40). That urea is one of the products of this important process, and that it constitutes the mode in which the greatest portion of the nitrogenized elements are excreted, is unquestionable. It is probable that the nitrogen present as a constituent of the quantity of urea excreted in twenty-four hours represents about five sixths of that taken into the system in the food. It must not, however, be supposed that the urea is normally derived *directly* from the food. Its origin must be traced to the destructive assimilation of those tissues of the body which are removed to make room for new matter. Minute quantities of urea escape from the system by the skin, but this body is removed so rapidly from the blood by the kidneys that very minute traces of it only can be obtained unless these organs become diseased, and are then no longer fitted to perform their important functions of depuration. It is a curious fact, first noticed by MM. Bernard and Barreswil, that,

in animals from whom the kidneys have been removed, the urea accumulates in the blood from the absence of its proper outlets, a considerable quantity is excreted by the gastro-intestinal mucous membranes in the form of carbonate of ammonia, a result of the re-arrangement of its elements (77). In man, and in all warm-blooded carnivorous and omnivorous mammalia, the quantity of urea far exceeds that of uric acid; whilst, in carnivorous birds, serpents, and insects, the latter substance predominates, and often quite replaces the urea. Dr. Prout is inclined to believe that the urea is the peculiar product of the metamorphosis of the gelatinous, and uric acid of albuminous, structures.[19] Liebig, on the other hand, considers that uric acid is the immediate product of the change in all nitrogenized tissues, and that urea is the secondary product, arising from the action of oxygen and water in the uric acid.[20] The fact that in sea-birds and many insects the uric acid remains in the state of urate of ammonia, and does not become converted into urea, notwithstanding all the conditions necessary, according to Liebig's views, for this change to exist, must cause this hypothesis to be received with great caution.

The following table shows the average quantity of nitrogen and carbon evolved from the system in twenty-four hours in the form of urea and uric acid:

Quantity excreted in 24 hours.		Nitrogen existing in	Carbon existing in	Nitrogen calculated in cubic inches.
	Grains.	Grains.	Grains.	Cubic inches.
Urea	255·	118·95	50·92	391·4
Uric acid . . .	8·1	2·52	3·23	8·3
Total . .	263·1	121·47	54·15	399·7

Urea is not alone eliminated from the blood by the

kidneys; it has been detected in many of the fluid secretions, and among others in the humours of the eye. I have found it abundantly in the perspiration of persons whose kidneys are unhealthy, and in the copious evacuations from the intestines produced in renal dropsy by the action of elaterium.

It is impossible to overlook the curious relations existing between urea and sulpho-cyanide of ammonium, in connection with the fact of the excretion of sulpho-cyanogen in the saliva. The presence of an alkaline sulpho-cyanide can readily be demonstrated by the production of the characteristic red colour on adding a few drops of a solution of any sesqui-salt of iron to the saliva. Sulpho-cyanide of ammonium may be regarded as urea, in which oxygen is replaced by sulphur, thus:

Urea (cyanate of ammonia) $= C_2, N_2, H_4, O_2$;
Sulpho-cyanide of ammonium $= C_2, N_2, H_4, S_2$.

75. The influence of the composition of food on the quantity of urea is beautifully shown by the experiments of Dr. Lehmann,[22] of Leipsic. This philosopher examined the quantity of urea secreted by his kidneys whilst living for some days on a strictly animal diet, as well as when he restricted himself to vegetable food, to a mixed diet, and to one quite free from nitrogen, consisting of starch, gum, oil, sugar, &c. The mean weight of the urea obtained from the urine of twenty-four hours, under these circumstances, is expressed below in grains:

Diet.	Animal.	Vegetable.	Mixed.	Non-nitrogenized.
Urea in the urine of twenty-four hours . . .	819·2	346·5	500·5	237·1

No one can avoid observing the great disproportion ex-

isting between the quantity of urea contained in Lehmann's urine, and that generally assumed as the average; the amount secreted whilst confined to a strictly non-nitrogenized diet, nearly equalling the normal proportion. Still, whatever may be the idiosyncracy of the ingenious experimenter in this matter, the result of his researches prove to a demonstration the influence of food in modifying the proportion of urea separated by the kidneys. I cannot help suspecting that the appetite of this physiologist must be rather above the average, for he alludes to his having devoured thirty-two boiled eggs in one day, which, even in the absence of other food, seems an enormous quantity. Lehmann has also shown that the excretion of urea is considerably augmented by anything which, like severe muscular exertion, increases the wear and tear of tissues.

M. Lecanu[28] has made some interesting observations on the connection between the amount of urea secreted and the age of the individual. The following presents the average results of his experiments on the quantity of urea and uric acid excreted in twenty-four hours at different ages:

	Urea.	*Uric acid.*
Adult men	431·9 grains. . . .	13·09 grains.
Adult women	294·2 ,, . . .	10·01 ,,
Very old men (84 to 86 years old)	124·8 ,, . . .	6·77 ,,
Children (under 8 years) .	138·2 ,, . . .	3·98 ,,

Bischoff's observations on this subject are worthy of our careful study, and are clearly expressed in the following table from Dr. Day's "Contributions to Urology," in the 'British and Foreign Medico-Chirurgical Review,' July, 1855:

	3 years.	3½ years.	4 years.	5 years.	7 years.	18 years.	22 years.	31 years.	38 years.	65 years.
	1000 parts contained									
Water	966·39	965·39	955·89	941·23	969·91	967·37	965·32	967·95	959·53	977·39
Solid constituents	33·61	34·61	44·11	58·77	30·09	32·63	34·68	32·05	40·47	22·61
Urea	15·34	17·19	20·25	26·11	16·98	14·61	12·52	16·44	16·93	7·82
Other organic matters	3·57	2·87	5·51	9·90	3·61	4·60	11·21	6·41	11·66	9·54
Fixed salts	14·70	14·55	18·35	22·76	9·50	13·42	10·95	9·20	11·88	5·25
	In twenty-four hours there were discharged, in grammes,*									
Water	374·26	728·87	758·04	680·98	1044·60	2472·43	2081·430	2343·41	1689·773	2396·63
Solid constituents	29·74	26·13	33·96	41·02	32·40	81·57	74·970	76·59	71·227	54·37
Urea	13·57	12·98	15·59	18·22	18·29	36·52	27·008	39·28	29·824	19·17
Other organic matters	3·17	2·17	4·25	6·92	3·88	11·50	24·335	15·33	20·484	12·31
Fixed salts	13·00	10·98	14·12	15·88	10·23	33·55	23·627	21·98	20·919	12·89
	For every pound weight of the body there were excreted in twenty-four hours, in grammes,									
Water	36·050	25·133	25·430	22·660	26·115	23·540	18·584	17·010	13·518	23·140
Solid constituents	1·226	0·901	1·318	1·367	0·810	0·776	0·669	0·563	0·569	0·523
Urea	0·526	0·447	0·605	0·607	0·457	0·347	0·241	0·288	0·238	0·184
Other organic matters	0·130	0·075	0·165	0·230	0·097	0·109	0·217	0·112	0·164	0·214
Fixed salts	0·536	0·378	0·548	0·529	0·256	0·319	0·211	0·161	0·167	0·124

* One gramme = 15·4336 grains.

76. Urea is invested with peculiar interest on account of its being so readily obtained artificially, and thus enabling the chemist to closely imitate one of the most important results of the chemistry of life. A man eats an excessive meal of meat, more than he can assimilate into healthy blood, and a large proportion of it, under the influence of the water, alkali, and oxygen of arterial blood, becomes metamorphosed into urea. The chemist can take some of the same meat, and ignite it with carbonate of potass; the result is, that carbon and nitrogen unite to form cyanogen; he adds a body which readily yields up oxygen as the binoxide of manganese, and a cyanate of potassa is formed. This, when digested with a salt of ammonia, becomes a cyanate of that base, which requires only a rearrangement of its elements under the influence of heat to become urea. Thus—

	C N H O
1 atom cyanic acid . . .	2+1+0+1
1 ,, water . . .	1+1
1 ,, ammonia . . .	1+3
=1 ,, urea . . .	2+2+4+2

77. As urea consists of 2 at. carbon, 4 at. hydrogen, 2 at. nitrogen, 2 at. oxygen, its elements are so arranged that its composition exactly resembles that of carbonate of ammonia, minus two atoms of water.

	C N H O
2 atoms carbonic acid . .	2 4
+2 ,, ammonia . .	2+6
	2+2+6+4
−2 ,, water . . .	2+2
=1 ,, urea	2+2+4+2

In accordance with this view, urea is decomposed by boiling with a concentrated acid, a salt of ammonia being formed, whilst carbonic acid is evolved; and, on the other hand, by ebullition with a solution of potass, ammonia is given off, and a carbonate of potass remains. An ingenious mode of estimating the proportion of urea existing in any fluid, founded on becoming so readily converted into an ammoniacal salt, has been proposed by M. Heintz.[119] The fluid being mixed with an excess of sulphuric acid, is slowly evaporated in a retort until fumes of sulphuric acid begin to rise, a sulphate of ammonia is formed, and carbonic acid given off. The quantity of ammonia in the salt, estimated by precipitation by chloride of platinum, or the amount of carbonic acid evolved, becoming an index of the urea present; 44 grains of carbonic acid indicating 60 of urea. The mere act of boiling the urine is sufficient to convert a portion of urea into an ammoniacal salt, and by long keeping, even in close vessels, a similar change occurs. The rapidity with which this conversion is effected varies remarkably in different specimens of urine. I have known urine become alkaline within an hour of its emission, and yet, in one instance, I detected urea in a specimen of urine which had been preserved in a closely stopped bottle upwards of ten years. The presence of a mucoid body in a state of change, acting as a ferment, certainly explains the rapid conversion of urea into carbonate of ammonia, in some urine (274).

Dr. Hassall compares this passage with the following statement by Dr. B. Jones: "Pure urea may be kept dissolved in distilled water, or it may, as you see in this test-tube, even be boiled without being changed into carbonate of ammonia; but if a few drops of ammoniacal urine, or a small quantity of mucus, is added, decomposi-

tion begins. By careful experiments, more may be made out on this subject than the general fact that some substance in a state of change is requisite to cause the change in the urea to begin; and the influence of the monads and vibrios, which are sometimes found in acid urine, may be determined." These two statements are not in such direct opposition as has been supposed; inasmuch as boiling urine and boiling pure urea in distilled water are not quite the same things; indeed, the urine contains probably the very substance alluded to by Dr. B. Jones as requisite to cause the change in the urea to begin. However, there is no cause for complaint, as the matter has led to the institution of experiments, and the establishment of the following conclusions:

1st. The simple act of boiling an aqueous solution of urea is sufficient to determine the gradual dissolution of that substance, and its conversion into carbonate of ammonia.

2d. The conversion of urea takes place in distilled water, even without the aid of the spirit-lamp.

3d. The decomposition of urea is effected, either with or without heat, much more readily in fluids which are alkaline, and especially in those in which the alkalinity arises from the presence of lime in any form.

4th. The conversion of urea is retarded, and sometimes altogether prevented, by an acid condition of the fluid in which it is present; and this is equally the case whether the solution be subjected to the heat of the spirit-lamp or not. The more acid the fluid, the greater its power of resisting the decomposition of the urea.

5th. Animal matter, in a state of decomposition, exercises a powerful influence over the transformation of urea; and this it does partly by producing an alkaline condition of the fluid in which the two substances are contained,

the alkalinity being produced by the carbonate of ammonia generated during putrefaction (163).

The elements of urea not only are thus related to those of carbonate of ammonia, but are, as we have seen, identical with those of cyanate of ammonia with water, a circumstance which explains the occasional occurrence of cyanogen compounds in urine.

78. *Uric Acid.*—Chem. comp. C_{10}, N_4, H_4, O_6, C_2, H_4, N_2, $O_2 + 2\ C_4$, $NO_2 = 168$. (Syn. Lithic or Urylic acid.) From the analysis of healthy urine, we learn that on an average 8·1 grains of this substance is excreted from the blood by the kidneys in twenty-four hours. It has been lately suggested that uric acid always exists in the urine as a urate of soda; but it seems to me that the chemical evidence is more in favour of Dr. Prout's opinion, that the greatest proportion of the acid exists in combination with ammonia. From the accurate observations of this physician, we learn that uric acid requires 10,000 parts of water at 60° for solution, whilst there does not exist in urine quite 2500 times its weight. It is hence utterly impossible to be in a free state without supposing the existence of causes modifying its solubility, by no means justified by the present state of chemical knowledge. If, on the other hand, the acid is combined with ammonia, it must of necessity remain dissolved at ordinary temperatures. Urate of ammonia is soluble in 480 times its weight of pure water, and, in the state in which it occurs in urinary deposits, requires for solution 2789 parts of urine, according to the researches of Dr. B. Jones;[24] who has also shown that the presence of a moderate quantity of saline matter increases its solubility. The 8·1 grains of uric acid normally secreted in twenty-four hours requires but 0·82 grains of ammonia for saturation, and the 8·92 grains of urate of ammonia

thus formed would be held in solution by less than half a pint of water, or about one fourth the quantity separated from the blood by the kidneys. If healthy urine be slowly evaporated in an air-pump vacuum, it soon becomes turbid from the formation of clouds of urate of ammonia, which ultimately subside in very minute spherical masses on the sides of the vessel. The same thing occurs when urine of rather high specific gravity is exposed to cold. These facts appear conclusive in favour of Dr. Prout's opinion. The most plausible objection to this view is the one advanced by M. Becquerel and others, viz., that a single drop of nitric acid is sufficient to precipitate all the uric acid naturally contained in a considerable quantity of urine, which, it is stated, could hardly be the case if it were combined with a base. This is an objection more apparent than real, for if it be granted that 8·92 grains of urate of ammonia are dissolved in about 40 ounces of urine, a moment's reflection will show that less than a single drop of nitric acid ought to be sufficient to precipitate all the uric acid present in half a pint of urine. For the quantity of ammonia combined with the uric acid in half a pint would be about 0·2 grain, which would be exactly neutralized by 0·8 grain of nitric acid, or less than a single drop.

79. It is, of course, quite possible that uric acid may be secreted combined with ammonia from the elements of the disorganized albuminous tissues (82). It is, perhaps, more probable that the acid is first generated and subsequently unites with a base, which it meets, either in the nascent state, or in its progress through the structure of the kidneys. Late researches of Professor Liebig have thrown much light on this matter, in developing the reaction of alkaline basic phosphates with uric acid. It is well known that an aqueous solution of

the common or tribasic phosphate of soda exerts an alkaline action on reddened litmus paper. If uric acid be heated in such a solution, it dissolves in consequence of combining with part of the soda, and setting free part of the phosphoric acid, which probably forms a super-salt with some of the undecomposed phosphate.[25] The fluid thus becomes acid, and reddens litmus. On cooling, the phosphoric acid reacts on the urate of soda, and about one half the uric acid is deposited in fine *prismatic* crystals, resembling in shape some varieties of uric acid sand. These crystals are not pure uric acid, but contain, chemically combined, some phosphate of soda, of which they are not deprived either by boiling water or hydrochloric acid. The addition of an acid to the fluid decanted from the crystals causes a deposition of *tabular* crystals of uric acid. These observations are amply sufficient to explain the natural acidity of urine, and the deposition of crystals of impure uric acid on cooling; all that is required, being to suppose that the 0·398 grain of uric acid, the average quantity existing in 1000 grains, are dissolved in about 2·5 grains of tribasic phosphate of soda, the proportion found by Simon in that quantity of healthy urine.

80. The deposits most frequently occurring in the urine on cooling, by evaporation in vacuo, or exposure to a freezing mixture, are, however (133), neither crystalline nor composed of uric acid alone.

Lehmann states that "the sediment which is deposited from acid urine in fever, and in almost all diseases accompanied with severe fever, has long been misunderstood in reference to its chemical composition. Originally it was regarded as a precipitate of amorphous uric acid, and subsequently (and almost to the present time) it was regarded as urate of ammonia. It has, however, been fully demon-

strated by Heintz and myself that this sediment consists of urate of soda, mixed with very small quantities of urate of lime and urate of ammonia." And again, further on, he remarks that "he had scarcely found *any* ammonia in urine," in which statement he had been confirmed by Liebig, and also by Heintz, whose direct analysis had detected but $1\frac{2}{3}$ of ammonia in the sediment.*

And again, at p. 216: "Even in alkaline urine, it is very seldom that urate of ammonia occurs as a sediment. In these cases it is found in white opaque granules, which, as has been already stated, when seen under the microscope, appear as dark globules, studded with a few acicular crystals. It scarcely ever occurs except in urine which, by long exposure to the air, has undergone the alkaline fermentation. Even in the alkaline urine of patients with paralysis of the bladder dependent on spinal disease, it is very rarely that I have found these clusters of urate of ammonia. In the alkaline urine that is sometimes passed in other conditions of the system, it is never found."

Dr. Hassall, in a review of the last edition of this work, has given the analyses of five specimens of urine, in which he was ably assisted by Dr. Letheby; and as the subject is one of much importance and interest, and the experiments have been carefully made, I am happy to say that I have received Dr. Letheby's kind permission to insert them.

First specimen.—Colour, bright rose-red. Under the microscope it was found to consist of minute amorphous particles, which dissolved in warm water, and reappeared on cooling in their original state. Acetic acid slowly developed rhombic crystals of uric acid. The filter con-

* Lehmann, vol. i, p. 214.

taining deposit was treated with half an ounce of cold water in three portions. This removed a quantity of urea and a little of the urate. It was then drenched with boiling water, and the filtered liquid allowed to stand for twenty-four hours. The deposit was collected and dried at 7° Fahr. It weighed three grains. One grain was dried at 212°, and lost thereby 0·07 of moisture; it was afterwards incinerated, and furnished 0·092 of a white ash, which was very alkaline to turmeric paper, though not permanently so; it was fusible before the blowpipe, and tinged the flame of a violet-white colour. When dissolved in acetic acid, and tested with oxalate of ammonia, it gave a precipitate of oxalate of lime.

One grain was distilled with two drachms of weak potash, and it gave an alkaline liquid, which contained 0·012 of ammonia. While boiling, the potash solution acquired a bluish-green colour, showing the presence of uramile or murexide, to which the rose tint of the precipitate was doubtless due.

One grain was treated with weak acetic acid, whereby 0·66 of nearly colourless uric acid was obtained; the acetic solution gave a copious precipitate with oxalate of ammonia. These results prove that the precipitate consisted of bi-urate of lime, with a little bi-urate of ammonia, and a still smaller quantity of bi-urate of potash, together with colouring matter. The following is the per-centage composition:

Bi-urate of lime	61
" ammonia	13
" potash	traces
Moisture	19
Pink colouring matter (uramile or murexide)	7
	100

Second specimen.—The colour was at first of a bright rose-red, becoming of a foxy or yellowish-red tint after washing with cold water. The per-centage composition, obtained as in the former analysis, was—

Bi-urate of lime	70
,, ammonia	9
Moisture	16
Colouring matter	5
	100

The solutions from which the preceding were deposited, after cooling, were evaporated to dryness at a temperature of 100° Fahr., and were found to contain a small quantity of urea, together with bi-urate of lime and a little bi-urate of ammonia, but no urate of soda.

Third specimen.—The urine was deep brown, and the diffused sediment of a pale fawn tint, and when collected on filter of a light rose-pink, changing after some hours to a greenish hue, somewhat resembling pus. On submitting this urate to the microscope, it was seen that it had lost its usual granular form, and had become aggregated into small globular crystalline masses of a very pale colour and deliquescent appearance. The alteration of colour observed was, no doubt, owing to this change in the form of urate. The ash of the incinerated urate amounted to about 10 per cent., gave a permanent stain to turmeric paper, was soluble in water, and tinged the flame of the blowpipe of a violet colour, showing that it was chiefly composed of potash. 100 parts gave—

Bi-urate of potash	57·12
,, lime	18·37
,, ammonia	10·06
Moisture	11·74
Colouring matter and loss	2·71
	100·00

Fourth specimen.—This was of a bright deep pink colour, and was obtained from urine having a specific gravity of 1024, which, on evaporation of a few drops on a slip of glass, gave a crystalline crust of urea. It was treated with a large quantity of alcohol, by which a great deal of urea and a very little amorphous pink matter were dissolved out. Dried at 70° Fahr. its density was 1100. Ten grains were treated with half an ounce of cold water, and set aside for twenty-four hours; the water dissolved two grains and became of a pale sherry-tint colour. It yielded, on evaporation, a fawn-coloured deposit, which, being incinerated, gave 0·25 of white ash, which was found to be lime.

Two grains were treated with two drachms of dilute acetic acid, and after twenty-four hours, 1·2 grain of nearly white uric acid was obtained. Two grains were dried for several hours over a steam bath, and lost 0·2 from escape of moisture. The remainder was then distilled with two drachms of weak liquor potassæ, and the distillate contained 0·04 of free ammonia. Two grains were incinerated, and furnished 0·2 of white ash, which was found to be potash. These results give the following composition of the urate:

Bi-urate of potash	42·0
" lime	20·0
" ammonia	19·5
Moisture	10·0
Colouring matter and loss	8·5
	100·0

Fifth specimen.—Colour, dull pink. The ash amounted to 12·5 per cent.; it was strongly and permanently alkaline, and tinged the flame of a full yellow colour,

from which it is manifest that it consisted in great part of soda. The acetic solution was rendered slightly turbid by oxalate of ammonia, thus proving the presence of lime; and distilled with potash, gave evidence of ammonia. This specimen, therefore, consisted, in great part, of urate of soda, with a small quantity of urate of lime, and probably also of urate of ammonia.

In making analyses of the urates, certain precautions are necessary. The following is the best mode of proceeding. The filtering paper should be digested in acetic acid, in order to free it from lime or other salts which may be contained in it. The precipitate should be examined under the microscope, to ascertain whether it be free from oxalate of lime, uric acid, triple phosphate, or other deposits. It should be collected on the filter, well washed with proof spirit to remove urea and chlorides, and then dissolved in hot water, which should be poured upon the precipitate on the filter, stirring gently with a feather. Of course, as the water becomes cold, the urates are thrown down, when they may be collected and dried for analysis. If either triple phosphate or uric acid be present the filter will retain these, while the urates pass through, but if there be any oxalate of lime, its crystals may pass through the filter, and so vitiate the analysis.

It thus appears that the deposits usually considered to consist principally of urate of ammonia are, in reality, made up of urates of lime, potash, and soda, with very small quantities of ammonia—and even this is doubtful, as, from the great difficulty of freeing these deposits entirely from urea, it is possible that the ammonia may be derived from its decomposition.

As these views are ingenious, and are still supported by some chemists, I have hesitated to remove them, though myself persuaded of their fallacy. I believe

that the explanation of the proximate formation of these deposits is to be found in the action of uric acid on the microcosmic salt or double phosphate of soda and ammonia; which salt, or its elements, may be regarded as a constant constituent of healthy urine. When uric acid is mixed with a warm solution of this triple phosphate, urate of ammonia is formed, and phosphoric acid evolved, either free or combined with a base and forming an acid salt. This urate of ammonia is not decomposed on cooling, but is simply deposited in delicate microscopic needles, readily re-dissolving on the application of heat, if sufficient water is present. On the addition of urine to a hot solution of these minute needles, they are deposited on cooling, combined with the colouring matter of urine, completely amorphous, and presenting all the characters of the commonest forms of urinary deposits.[27] If, after the separation of the urate of ammonia, a fresh quantity of uric acid be heated in the supernatant fluid, more of the ammoniacal salt is formed up to a certain point; when phosphate of soda yields, and urate of soda is generated, which on cooling is decomposed in the manner already described (79).

81. I therefore ventured some time ago to propose the following as a probable explanation of the mode in which uric acid exists in healthy urine: *Uric acid, at the moment of separation from the blood, comes in contact with the double phosphate of soda and ammonia, derived from the food, forms urate of ammonia, evolving phosphoric acid, which thus produces the natural acid reaction of urine. If the whole bulk of the urine be to the urate of ammonia formed, not less than about 2701 to 1, the secretion will, at the ordinary temperature of the air, remain clear, but if the bulk of fluid be less, an amorphous deposit of the urate will occur. On the other hand, if an excess of uric*

*acid be separated by the kidneys, it will act on the phosphate of soda of the double salt, and hence, on cooling, the urine will deposit a crystalline sediment of acid sand, very probably mixed with amorphous urate of ammonia, the latter usually forming a layer above the crystals, which always sink to the bottom of the vessel.**

82. *Physiological origin of uric acid.*—It will be sufficient to merely allude to some of the more recent opinions entertained on this subject; and the first which demands attention is that of the celebrated Liebig.[28] He believes that when, in the exhausted tissues containing protein (*i. e.*, albuminous structures), the vital force is no longer able to resist the chemical action of the oxygen which is conveyed to them in the arterial blood (38), it combines with their elements and forms products, among which uric acid is the most important. Thus, the elements of one atom of the essential ingredients of all muscular and fibrous tissues (protein), with 91 atoms of oxygen, are equal to the elements of uric acid, carbonic acid, and water, thus—

$$\left.\begin{array}{rl} & \text{C}\quad\text{N}\quad\text{H}\quad\text{O} \\ \text{1 atom protein} = & 48+6+36+\ 14 \\ \text{91 ,, oxygen} = & 91 \\ \hline & \underline{48+6+36+105} \end{array}\right\} = \left\{\begin{array}{ll} \text{C}\quad\text{N}\quad\text{H}\quad\text{O} & \\ 15+6+\ 6\ +\ \ 9 = 1\tfrac{1}{2} & \text{at. uric acid.} \\ 33 \qquad\qquad 66 = 33 & \text{,, car. acid.} \\ 30+\ 30 = 30 & \text{,, water.} \\ \hline \underline{48+6+36+105} & \end{array}\right.$$

If, then, sufficient oxygen and water be conveyed in the arterial blood, the greatest part of the uric acid may be converted into urea and carbonic acid, so that the effete nitrogenized elements of the tissue reach the

* The presence of the ammonio-phosphate of soda in normal urine is much doubted by many observers; Lehmann, with Liebig and others, attribute the acidity of the urine to the presence of the acid phosphate of soda.

emunctories in a soluble form, a condition necessary for their ready excretion.

$$\left.\begin{array}{llr} & & \text{C}\ \ \text{N}\ \ \text{H}\ \ \text{O} \\ 1 \text{ atom uric acid} & = & 10+4+4+\ 6 \\ 4 \ \ ,, \ \ \text{water} & = & 4+\ 4 \\ 6 \ \ ,, \ \ \text{oxygen} & = & 6 \\ \hline & & 10+4+8+16 \end{array}\right\} = \left\{\begin{array}{ll} \text{C}\ \ \text{N}\ \ \text{H}\ \ \text{O} & \\ 4+4+8+\ 4 & = 2 \text{ atoms urea.} \\ 6 \qquad\quad 12 & = 6 \ \ ,, \ \ \text{car. acid.} \\ \hline 10+4+8+16 & \end{array}\right.$$

Dr. Garrod has shown, by a very ingenious series of experiments, that very minute traces of uric acid may be detected even in healthy blood. This is a very interesting fact, although what might have been expected, as the blood may be regarded as the main sewer into which are washed the results of the waste of the body prior to their final escape by their proper conduits. Professor Scherer[149] has discovered uric acid in comparatively large quantities in the spleen, and it appears, with hypo-xanthine (178), to be an important immediate result of the destructive metamorphoses of this singular organ.

83. It is, therefore, obvious, on the above hypothesis, that the larger the proportion of oxygen which circulates through a tissue in the act of destructive assimilation, the more complete will be the conversion of uric acid into urea, and in proportion as this oxygenation is perfected the former will disappear from the urine. Hence in the urine of carnivorous animals the quantity of uric acid in relation to the urea, will be in the inverse ratio of the rapidity of the circulation. Thus the boa-constrictor eats an enormous meal of nitrogenized food, but being a cold-blooded, slowly respiring animal, it takes in too little oxygen to convert the uric acid formed by the metamorphoses of its tissues into urea; and hence the semi-solid urine of this animal consists almost entirely of

bi-urate of ammonia. On the other hand, the lion and tiger, equally carnivorous with the serpent, are rapidly respiring, warm-blooded animals, and although, from their violent muscular exertions, rapid and great destruction of tissue must occur, scarcely a trace of uric acid is found in their urine, as it is all converted into urea at the moment of its formation, in consequence of the abundant supply of oxygen. As combination with oxygen is the necessary condition for the metamorphosis of tissue, it follows that we should be in constant danger of *oxidizing to death*, unless either the vital force is generated in sufficient intensity to oppose the action of oxygen, or some substance be present which, opposing a less resistance to its influence than organized tissues, protects them from corrosion. The mucus covering the air-passages and the bile in the intestines, are thus supposed to be the conservative agents which protect the structures imbued with them from destruction by oxidation. In a like manner the non-nitrogenized elements of our food, as all fatty and amylaceous substances, interfere with the conversion of the uric acid into urea, as they monopolise great part of the oxygen; hence man, being an omnivorous animal, partakes of a sufficient amount of food, rich in carbon, to prevent the complete conversion of insoluble uric acid into soluble urea, consequently the former substance appears in the urine. The average proportion borne by the uric acid to urea in healthy urine being about 1 to 32.

84. If these views be correct, it will follow that, other things being equal, the proportion of uric acid in the urine will increase in the urine of a man who takes food rich in carbon, and decrease if he confines himself to a nitrogenized diet, and becomes, for a time, a carnivorous animal. Further, the proportion of uric acid will de-

crease and urea increase, with the perfection of respiration and abundance of blood-discs, the reputed carriers of oxygen (35).

It appears, however, that these views, ingenious and full of interest as they are, are not supported by any experience hitherto recorded,—in fact, are, in many cases, totally opposed by it. Indeed we have no proof of any kind that uric acid is a necessary transition formation between protein-compounds and urea. The experiments of Lehmann already alluded to (75), performed upon himself, demonstrate that vegetable diet and one quite free from nitrogen decreases, and an animal diet increases, the quantity of uric acid; the urea also increases in the same manner. The following table presents the results of Lehmann's researches:

Diet.	Quantity excreted, in 24 hours, of		Proportion of uric acid to urea.
	Uric acid.	Urea.	
	Grains.	Grains.	
Exclusively animal . . .	22·64	819·2	1 : 36·1
Mixed animal and vegetable .	18·17	505·0	1 : 27·5
Exclusively vegetable . . .	15·7	346·5	1 : 22·
Food free from nitrogen . .	11·24	237·1	1 : 21·

From this table we learn that, when living on a diet as free from nitrogen as possible, 11·24 grains uric acid and 237·1 grains of urea were excreted by Lehmann's kidneys in twenty-four hours. These quantities may be assumed as solely produced by metamorphosis of tissue, inasmuch as there existed no other source for them. On confining himself to a strictly animal diet, Lehmann found in his urine 22·64 uric acid, and 819·2 urea, being 11·4 more of the former and 582·1 more of the latter than can be

accounted for by the disorganization of the tissues of his body, and, consequently, must have been derived from the ingesta. On mixing vegetable food with his meat, instead of finding an increased proportion of uric acid, as the theory of Liebig would indicate, a much smaller proportion of this substance was discovered in the urine.

The statement, that in carnivorous animals the use of vegetable food increases the amount of uric acid, is quite opposed to the fact recorded by Magendie,[29] that uric acid disappears from the urine of carnivora which have been fed for about three weeks on non-nitrogenized food.

85. The question, however, appears to be quite set at rest by the researches of Boussingault, performed on ducks. This very careful and laborious observer first carefully examined the quantity of uric acid excreted from the metamorphosis of tissue of the animal, by ascertaining the quantity excreted in a given time by a duck deprived of food for some hours; in another who had been made to swallow balls of clay; and a third who had been fed on gum—a body nearly free from nitrogen. He then proceeded to ascertain the increase of the acid excreted after the ingestion of various articles of food. I have arranged the following table from these experiments, having reduced their results to the same times—all the weights being calculated in English grains:

Uric Acid excreted by Ducks in 24 hours.

Food administered.	None.	Balls of clay.	Gum.	Casein.	Gelatine.	Gelatine.	Fibrine.	Flesh.
Quantity digested .	none.	none.	163·24	420·64	1400·8	1718·	635·2	956·34
Uric acid . . .	4·163	4·163	4·412	162·4	157·08	203·28	138·6	291·0
Nitrogen in the food	none.	none.	?	66·54	271·1	311·76	99·82	149·136
Nitrogen in the uric acid . .	none.	none.	?	55·59	51·83	67·08	45·7	96·03

This tabular view of Boussingault's researches is peculiarly instructive, and places beyond all doubt the real office of uric acid, at least in those animals which normally excrete their useless nitrogenized elements in that form. Analogous experiments of Lehmann and others, as we have seen, have shown that urea performs a similar function in man. The only difficulty investing the subject is simply the question, why urea is sometimes the form in which nitrogen is evolved, and why, at others, uric acid performs this function. That the view of Professor Liebig is untenable I have already expressed an opinion, and some serious objections are opposed to the notion of uric acid being, in man at least, the result of the metamorphosis of one set of tissues, and urea of another, since that in ducks, in Boussingault's experiments, not a trace of urea was excreted, although carefully looked for, and yet structures physiologically identical with those of man and of carnivorous animals, must have undergone metamorphosis. The true physiological relation of urea to uric acid is still one of the *desiderata* of science.

86. Dr. B. Jones has more recently re-examined this subject, but chiefly in relation to the *immediate* influence of food, and not to the total quantity excreted in 24 hours. He found that the quantity of uric acid—

After animal food in 1000 grs. of urine, sp. gr.	.	1·027 was	1·022 grs.
Before ,,	,,	1·024	0·049
After vegetable food	,,	1·025	1·010
Before ,,	,,	1·024	0·049

Exercise did not appear to materially affect the quantity of uric acid excreted.

87. The theory of the perfection of oxidation in increasing urea and diminishing the uric acid, scarcely appears

to be in accordance with the well-known fact, that in carnivorous birds, as sea-fowl, the mortar-like urine is constituted of urate of ammonia, like the urine of serpents, and yet the former class of animals are rapidly respiring, warm-blooded animals, provided with an abundance of oxygen, totally opposed to the serpents in their physiological characters, and appearing to present all the conditions required by the theory alluded to for the total conversion of uric acid into urea. This change, nevertheless, does not occur, and so large a quantity of urate of ammonia is excreted by sea-birds, that many islets and rocks in the tropics inhabited by them are covered to a considerable depth with this substance, which is now an important article of commerce as a manure, under the name of *guano*. Zimmermann[30] attempted to defend Liebig's view against the objection, on the ground that the feathered skins of birds prevented contact of air to capillaries of the surface, and thus cut off one supply of oxygen. This remark, however, applies with equal force to the thick hides of the lion, tiger, and leopard, as well as to the scaly armour of serpents, and hence gives no support to either opinion.

88. From a late observation by Heller,[120] it will appear, that of all animals, in proportion to their size, butterflies excrete the largest quantity of uric acid combined with ammonia. This substance appears to be a product of metamorphic changes of tissue during the pupa state, as it does not exist in the caterpillars; and the yellow fluid which is excreted when the developed insects escape from the pupa is rich in urate of ammonia. If a butterfly be caught, and gentle pressure be applied to its abdomen, the drop or two of yellow fluid which escapes contains urate of ammonia in globules, and coloured by purpurine. Dr. John Davy has very recently shown that all true

insects he had an opportunity of examining in Barbadoes, excreted uric acid free or combined. Spiders, on the contrary, excrete uric oxide. This question will, however, again come before us.

89. What, then, is to be regarded as the physiological source of the uric acid of the urine? There can be no question that all the phenomena of health and disease point out the probability of there being a double origin of this substance, one from the nitrogenized elements of tissues, and the other from the elements of food rich in nitrogen which escape the completion of the process of primary assimilation, or undergo the changes consequent on that function so imperfectly as not to be completely converted into the healthy constituents of blood. They hence yield with facility to the metamorphic influences so energetically exerted in the capillary network of the body, and their ultimate elements are excreted as uric acid generally combined with soda, lime, &c. Why they are thus excreted at one time as uric acid, or urates, and at another as urea, we are, as I have already stated, quite ignorant.

90. *Lactic acid and lactate* (?) *of ammonia.*—The existence of these compounds in healthy urine, first announced by Berzelius, and admitted generally by chemists, has been called in question by Professor Liebig, who, in a careful repetition of the processes of Berzelius, failed in detecting the slightest evidence of the presence of the lactic acid. It appears evident that what was mistaken for lactic acid is really a mixture of creatine and creatinine, discovered by Dr. Pettenkofer (93). Lehmann[31] has stated that 1·52 grain of free lactic acid, and 1·20 grain of lactate of ammonia, are contained on an average in 1000 grains of healthy urine. Since the detection of the nitrogenized bodies just alluded to, these numbers must be regarded as indicating rather the proportion of

this substance, and not of lactic acid or a lactate, as was previously supposed.

The composition of dry lactic acid ($C_6, H_5, O_5 = 81$) bears so simple a relation to that of some of the most ordinary elements of our food, that its presence in the secretions, at least under many circumstances, might really be anticipated. Thus the elements of—

1 atom	of starch	are equal to 2 atoms of lactic acid	
1	" cane-sugar	"	+ 1 atom of water.
1	" gum	"	" "
1	" milk-sugar	"	+ 2 atoms of water.
1	" grape-sugar	"	+ 4 "

Lactic acid can be readily formed out of the body by allowing a solution of sugar to ferment in contact with an animal substance in a state of change, as the mucous membrane of a calf's stomach (rennet), or a piece of washed cheese (caseïn).

91. Liebig has lately shown[144] that Berzelius was not in error when he announced lactic acid to be a constituent of the juices of the flesh; and as no appreciable quantity of it is to be detected in the urine in health, it must undergo some secondary change before its elimination from the system.* It in all probability undergoes oxidation, becoming converted into carbonic acid, as occurs out of the body when it is heated in contact with the fixed base. Thus—

	C	H	O
1 atom lactic acid . . .	6 +	5 +	5
+12 atoms oxygen . . .			12
	6 +	5 +	17
— 5 atoms of water . . .		5 +	5
= 6 atoms of carbonic acid . .	6 +		12

* Lehmann states that it is present in those diseases in which there is an

A certain, although small portion, of lactic acid is, there is some reason to believe, excreted in the perspiration, even in health. In some diseases, it certainly escapes freely from the skin.

92. From the late researches of M. Boussingault, it appears quite certain that lactic acid is an ingredient in the urine of herbivorous animals. He detected distinct traces of it in the urine of a pig fed upon potatoes, whilst in the urine of a cow and horse he found respectively 16·51 and 20·09 parts of an alkaline lactate in 1000 of urine. When the quantity of lactic acid is exceedingly small, the test proposed by M. Pelouze for its detection may be employed.* This is founded on the property possessed by lactic acid of preventing the complete decomposition of salts of copper by alkalies. For this purpose boil the urine to be examined with milk of lime until the urea is completely decomposed, and ammonia ceases to be given off. The filtered fluid should be mixed with a solution of the sulphate of copper, by which, if lactic acid be present, a lactate of copper is formed, and, on adding some milk of lime, oxide of copper will be precipitated. On throwing the whole on a filter, the fluid which passes through will be found free from copper, unless lactic acid be present, in which case distinct traces of the metal can be detected, by acidulating the fluid with a drop of sulphuric acid, and immersing a polished piece of iron wire, which will become in a short time coated with copper. I must confess, however, that I do not feel much confidence in this test of M. Pelouze.

increase in the amount of the oxalate of lime, as in pulmonary emphysema, disturbances of the nervous system, rachitis, &c.

* Fresh urine ought always to be used, in order to avoid the fallacy arising from the changes due to urinary fermentation according to the views of Scherer.

93. *Creatine and creatinine.*—These very interesting substances, of which some account has already been given (40), were first discovered in the urine by Dr. Pettenkofer, and were supposed to be peculiar to that secretion, until Professor Liebig, after some masterly researches, proved them to be identical with the crystallized body described many years ago by Chevreul in the juices of flesh. Evidence of their existence in the urine may be obtained in the manner already described (6), but to procure them in any quantity the process described by Liebig is by far the best. He removes the acidity of healthy urine by the addition of a little lime, and then adds chloride of calcium, until no further precipitate of phosphate of lime takes place. The filtered fluid is then evaporated to a syrupy consistence, and after the crystallization of salts from it, the supernatant fluid is decanted, and mixed with a saturated solution of chloride of zinc in the proportion of half an ounce to a pound of the extract of urine. In a few days, an abundant deposit of yellow granules, generally closely adhering to the vessel, will have appeared. These consist of a compound of the chloride of zinc with the creatine and creatinine. They should be washed in cold water, then dissolved in boiling water, and recently precipitated oxide of lead added until the fluid becomes strongly alkaline. Chloride of lead is thus formed, and, with the separated oxide of zinc, is precipitated. The whole is thrown on a filter with a little animal charcoal, the clear solution passes through, and, on being evaporated, leaves a crystalline mass; on digesting this with hot alcohol, creatinine is dissolved, and creatine left.

Creatine (Chem. comp.: C_8, N_3, H_9, O_4, + 2HO = 131 + 18 = 149) occurs in colourless, transparent, lustrous, rhombic crystals, is perfectly neutral, and crystallizes from

its solutions in tufts, like acetate of lead. They contain about 12 per cent. of water of crystallization, are soluble in 74·4 parts of cold water, and are nearly insoluble in strong alcohol. It is of a bitter, strongly pungent taste, and irritating to the fauces. It loses its two atoms of water at 110°, and is decomposed at a higher temperature. It is soluble without change in baryta water; but when boiled with it, it is decomposed into ammonia and carbonic acid, or urea and sarcosin. It is soluble without change in dilute acids; but when heated with strong acids, it gives off its two atoms of water, and is converted into creatinine. Creatine contains, when dry, nearly 32 per cent. of nitrogen.

Creatinine (Chem. comp.: C_8, N_3, H_7, O_2 = 113) contains 24 per cent. of nitrogen, and differs essentially from creatine in exerting a strongly alkaline reaction. It crystallizes from its aqueous solution in small, colourless, glistening prisms; is soluble in 11·5 parts of cold water, and about 100 parts of cold alcohol. It forms a series of salts with acids, and has a remarkable tendency to yield triple compounds with metallic salts, especially those of silver, mercury, zinc, and platinum. A solution of creatinine instantly throws down from nitrate of silver a deposit of a triple salt in white acicular crystals. Creatine and creatinine bear a simple relation to each other, thus—

	C N H O
1 atom creatine . . .	8+3+9+4
—2 atoms water . . .	2+2
=1 atom creatinine . . .	8+3+7+2

Accordingly we find that creatine is converted into creatinine with great readiness by digestion with the mineral acids. During putrefaction of fluids containing

it, this change in all probability occurs, for no creatine can be detected in putrid urine, the creatinine alone existing. Even in healthy urine the quantity of creatine is much smaller than that of the creatinine, and is very variable; indeed, it may be doubted whether it can be regarded as a perfectly normal ingredient.

94. *Physiological origin of creatine and creatinine.*—It is impossible to doubt the really excrementitious character of these bodies; we have already seen that one of them, the creatine, is formed in considerable quantity in the infusions of muscular tissue, and as it is removed from the body by the kidneys, partly unchanged and partly converted (by giving up two atoms of water), into creatinine, it can only be regarded as one of the forms under which we find the nitrogenized elements of worn-out structures removed from the system. In this point of view both these bodies are invested with no small interest. What at first appeared as a mere chemical curiosity, becomes in this view a physiological substance, performing the important function of depurating the blood. It appears probable that creatine and its allies, creatinine and inosinic acid, are the direct result of the metamorphoses of certain structures, and that others tend, from some cause yet to be made out, to undergo conversion into other elements. Thus Liebig found creatine in the infusions of the muscles of all the mammalia he examined, as well as in fowls, fish, and probably in the alligator; whilst it was totally absent from the brain, liver, and kidneys of animals. It would appear that the quantity of creatine bears a ratio to the wear and tear of the muscular structures; thus, in wild and hunted animals the quantity was far greater than in domesticated and tame ones, even when allowance was made for the greater quantity of fat existing in the latter.

The heart, a never-resting muscle, yields the largest proportion of creatine.

While it would be premature to assume as proven any views not as yet demonstrable, it may still be considered as probable that creatine is an early link in the stage of metamorphic changes to which muscular structures are subjected before their final elimination in the elements of the excretions. The recent discoveries of Scherer would render it probable that other organs, as the spleen, are metamorphosed into hypoxanthine (178), a body distinct from creatine. It is hence rendered very possible that all tissues are not resolved into the same elements of excretions, and some confirmation is afforded to the views of Dr. Prout, who was disposed to trace the origin of several of the elements of the urine to the destructive assimilation of distinct tissues.

95. Although we have seen that creatine and creatinine are both found in the urine, we must not conclude that they are entirely excreted in this manner. It is very probable that a considerable proportion of creatine is resolved into uric acid or urea before its final elimination. We have already seen the chemical relation of creatine to uric acid, and to urea (40); its metamorphosis into the latter body, and into the peculiar substance, sarcosin (which requires only the addition of the constituents of water to represent the elements of lactate of ammonia) is so readily effected, that a similar change occurring in the body is rendered very probable.

96. *Hippuric acid.*—Chem. comp. C_{18}, H_8, N, O_5 + HO=176. (Syn. Urobenzoic acid.) This substance, long known to exist in the urine of herbivorous animals, and, according to some, occasionally in that of man, has been shown by Liebig to be a normal constituent of the latter fluid. Its presence can be demonstrated in the

urine of the horse and cow with great readiness, by merely acidulating some of that fluid with hydrochloric acid, and after effervescence has ceased, filling a watch-glass with the mixture, and leaving it to evaporate spontaneously; in a few hours delicate tufts of acicular crystals of hippuric acid will appear. The best mode of obtaining this substance from healthy urine is to evaporate a few ounces of urine to a very small bulk, and then add an excess of hydrochloric acid. A mixture of hippuric and uric acids with altered colouring matter will then be separated and fall to the bottom of the vessel. After a few hours' repose the supernatant fluid should be decanted, and the deposit washed with a small quantity of very cold water. On boiling the residue with alcohol, in which uric acid is insoluble, the hippuric acid will be dissolved, and, by spontaneous evaporation, be left in thin, delicate needles, strongly coloured from adhering impurities. Hippuric acid, when pure, crystallizes in long, slender, four-sided, acuminated crystals, and requires nearly 400 times its weight of cold water for solution, and hence can be separated from even a dilute solution of any of its alkaline salts by the addition of a stronger acid.

97. When an abnormally large proportion of this acid is present, as after the administration of benzoic acid (160), or green plums, or in hippuria (201), it is easily detected by pouring about half an ounce of the urine into a capsule, and evaporating to a syrupy consistence. On adding an equal bulk of hydrochloric acid, and allowing the whole to cool, a crystallization of hippuric acid in pinkish tufts of acicular crystals will occur. This is beautifully shown with the urine of the horse, or of a person who has taken half a scruple of benzoic acid a few hours before. If the quantity of hippuric acid is small, it frequently crystallizes on the addition of hydrochloric

acid, in a very curious manner, in delicate linear branched figures, ramifying in the fluid like a sea-weed, or a leafless bunch of twigs (202).

A quantity of purpurine usually falls with the hippuric acid, so that, when drained on a filter, the paper is stained of a delicate carmine colour—a remarkable fact, when we bear in mind the close approximation existing between hippuric acid and purpurine (98).

Hippuric acid must also exist in the semi-solid urine of birds, as E. Marchand detected it combined with ammonia in guano.[121]

98. *Physiological origin.*—It is believed by its discoverer to be a derivative of some of the non-nitrogenized elements of food, and to exist nearly in the same proportion as uric acid. The quantity of hippuric acid in the urine, from the experiments of Heller, appears to be dependent in great measure on diet; for he found that a diet consisting of wheat- and rye-bread, or, still better, rye-bread alone, produced a urine rich in hippuric, but almost void of uric acid; and on afterwards adopting a mixed diet, including meat, the relations of the two acids were reversed, hippuric acid disappeared, while the quantity of the uric acid increased. From my own researches, whilst they fully agree with the results of Liebig as to the existence of hippuric acid, I am inclined to believe that its quantity, in health, is not constant, and always, unless after the ingestion of benzoic or cinnamic acids, very much less than has been stated. It is possible that hippuric acid may constitute a means by which carbon may be evolved from the system by the kidneys, and it is probable that in cases in which the proper emunctories of this substance, the lungs and the liver, are deficient in their function, the kidneys may partially compensate for this by secreting a larger portion of hippuric acid.

It has very recently been detected in the blood of the ox, and hence its presence in the urine of that animal is readily accounted for. It is remarkable that hippuric acid, next to the bile and purpurine, is the richest in carbon of any of the products of vital chemistry, and hence it very probably performs an office of great importance in the body. A comparison of the per-centage composition of the organic material of human bile, from the analysis of Dr. Kemp, with that of anhydrous hippuric acid, and the colouring matter of urine from Scherer's analysis (102), will show the relation between them, *quoad* the amount of carbon.[32]

	Bile.	*Hippuric acid.*	*Urinary colouring matter.*
Carbon	68·40	63·93	58·43
Hydrogen	10·13	4·64	5·16
Nitrogen	3·44	8·21	8·83
Oxygen	18·03	23·22	27·58
	100·	100·	100·

99. *Butyric acid.*—Occasionally present in urine, and in all probability owes its origin to an imperfect assimilation of saccharine matter. It may, however, be possibly generated occasionally from the butter which forms so large a portion of our food. As a product of disease, it is met with in the white creamy deposit occasionally observed in diabetic urine. The opinion of the origin of this acid being traceable to a change in the elements of sugar, is supported by the fact that out of the body it may be generated by digesting a solution of sugar with a piece of curd of milk, which plays the part of a ferment, the sugar being converted into butyric acid with the evolution of hydrogen and carbonic acid.

$$\left.\begin{array}{lr} & \text{C}\quad\text{H}\quad\text{O} \\ \text{1 atom of sugar} = & 12+10+10 \\ \text{2} \;\;,,\;\; \text{water} = & 2+\;\;2 \\ \hline & 12+12+12 \end{array}\right\} = \left\{\begin{array}{ll} \text{C}\quad\text{H}\quad\text{O} & \\ 8+\;\;8+\;\;4 & = \text{1 atom butyric acid.} \\ 4+\qquad\;\;8 & = \text{4} \;\;,,\;\; \text{carbonic acid.} \\ \qquad\;\;4 & = \text{4} \;\;,,\;\; \text{hydrogen.} \\ \hline 12+12+12 & \end{array}\right.$$

This acid may also be derived from protein-compounds, for it has been observed that, when moist fibrin is exposed to the air for some days, it undergoes metamorphosis, becoming partly liquid, and evolves a strong odour of cheese. Carbonic, acetic, and butyric acids with ammonia are generated; and on distilling the residual mass with sulphuric acid, the two latter acids pass over into the receiver.

100. *Colouring matter of urine.*—The nature of the pigment which communicates the characteristic tint to urine is quite unknown. By the late Dr. Simon it was regarded as identical with hæmaphaein,[33] the matter which gives to serum of blood its yellow colour, and to whose presence in excess the jaundiced hue of the surface, so common in new-born infants as well as in cases of chlorosis and anæmia, is supposed to be owing. Dr. Prout has suggested that two distinct pigments probably exist, one of them remarkable for its power of uniting with the urates and communicating to them the fawn colour so characteristic of these salts in urinary deposits. Berzelius has indeed described such a yellow colouring matter under the name of *halophyle*, a term applied to it from the remarkable obstinacy with which it adheres to the urinary salts. Ether readily extracts from inspissated urine a golden-yellow acrid matter. Heller has given the name of *uroxanthin* to the reputed pigment, but which he has not succeeded in separating. According to him, this body is characterised by its undergoing oxidation by

the action of acids, and, under the influence of disease, giving rise to *uro-glaucin*, a blue, and *uri-rhodin*, a red pigment. These, however, are merely applied to what I have long ago described as purpurine. Heller has indeed correctly stated that these metamorphosed varieties of the urinary pigment may fall as insoluble deposits, but he has described as crystals of uro-glaucin, uric acid merely tinted by the changed colouring matter. This error is an important one, and throws much doubt on many of his conclusions.

A very characteristic reaction of this matter was pointed out by myself some years ago, founded on the action of hydrochloric acid upon previously warmed urine. When a test-tube is about one third filled with healthy urine and raised to a boiling heat, the subsequent addition of a few drops of hydrochloric acid produces a tint varying, according to the proportion of colouring matter present, from a delicate lilac to the deepest crimson. The substance thus generated I have always regarded as identical with that excreted by the kidneys in certain diseases (especially those connected with the imperfect elimination of carbon), and which communicates the peculiar hue to the so-called pink deposits.

101. The pink pigment thus generated under the influence of disease, or by the action of hydrochloric acid, is readily soluble in weak hot alcohol, communicating to it a yellowish-pink colour, and is remarkable for the facility with which it unites with the urates. If some of these salts, free from all colour, be dissolved in a warm solution of the pink pigment, or in urine containing it, they are deposited on cooling of a pink hue, having absorbed the colouring matter like a mordaunt, just as alumina carries down with it the colouring matter of cochineal. To this pigment I proposed to give the name

purpurine, and it is, I presume, identical with what Simon afterwards called uro-erythrine, and Heller, more lately, ur-rhodin.*

102. The researches of Professor Scherer,[140] of Wurtzburg, on the yellow extractive of urine, are highly important. He has supposed that this substance is the direct result of the destructive assimilation of old blood-corpuscles. The following is the mode he recommends for its preparation: Precipitate urine by basic acetate of lead; the deposit, consisting of a combination of the colouring matter and the acids of the urine with lead, is digested in alcohol acidulated by hydrochloric acid. The lead is thus separated from the animal matter in question as an insoluble chloride. The alcoholic solution yields, by careful evaporation, the colouring extractive, of course more or less modified by the action of the acid, in the form of a blackish mass. By washing with water, the acid may be removed, and a scarcely soluble blackish-brown powder is left by careful desiccation. If neutral acetate of lead be substituted for the basic salt, a much smaller quantity of animal matter is precipitated, but it appears to be richer in carbon. This, among other circumstances, leads to the conclusion that the substance termed by Scherer colouring matter of urine, is really a mixture of two or more bodies, and justifies our adopting this as a mere conventional term.

Scherer found this substance, obtained from the urine of a healthy person, to consist of—

Carbon	58·43
Hydrogen	5·16
Nitrogen	8·83
Oxygen	27·58

* Heller alludes to uro-xanthin and uro-glaucin as well as ur-rhodin, but of

These researches invest the hitherto neglected colouring matter, or extractive of urine, with high physiological importance. It must for the future be regarded as a vehicle for the excretion of carbon from the blood by the kidneys, and these glands thus appear, in all probability, to play no mean part in compensating for a deficient function in those organs whose especial duty it is to secrete carbon, as the liver and lungs. To this matter we shall again return when speaking of purpurine (186).

By loading the system with carbon, or by preventing its due elimination, an excess of this element has been proved to escape by the kidneys. Of the former, a good illustration is met with in the urine of a healthy man who for three weeks daily swallowed a large quantity of cod-liver oil; and of the latter, the urine of a person suffering from considerable pleuritic effusion will serve as an example:

	Colouring matter of urine before the use of cod-liver oil.	Colouring matter of urine after the use of cod-liver oil.	Colouring matter of urine of the case of pleuritic effusion.
Carbon	56·65	57·22	61·65
Hydrogen	4·10	5·46	5·60
Nitrogen	6·25	37·32	7·29
Oxygen	33·00		25·46

103. *Sulphur extractive.*—It has been long known that urine contained sulphur in an unoxidized state, and attention was drawn by the early chemists to urine blackening a silver vessel in which it was boiled. Professor Ronalds (now of Queen's College, Galway) some

these three uro-glaucin is the only one whose existence is in any way clearly established; the experiments with regard to the other two were too incomplete to admit of any conclusion.

time ago undertook some researches on this subject, and he discovered that after the colouring extractive matter just described was precipitated by basic acetate of lead, the filtered fluid held in solution, besides urea, a peculiar matter, containing a large proportion of sulphur, and a small quantity of phosphorus. This matter has not been isolated, but it furnishes a medium for the elimination of at least from three to five grains of sulphur in twenty-four hours.

The physiological origin of sulphur extractive is undoubtedly to be found in the metamorphosis of part of the albuminous and fibrinous tissues; these all contain sulphur and traces of phosphorus. Whilst the greater quantities of their protein elements are converted into creatine and its allies, and urea, a small proportion containing the sulphur and phosphorus is eliminated by the kidneys in the form of this peculiar extractive matter. The taurine, a crystalline body into which a part of the constituents of the bile are readily resolved, contains one fourth of its weight of sulphur, and may therefore be one of the sources of the sulphur extractive of the urine.

104. *Ammonia.*—The presence of this alkali in the urine has been doubted by many late observers, except as a product of decomposition of urea or other elements. Lehmann asserts that on treating fresh healthy urine, *previously concentrated by freezing*, with bichloride of platinum and potassium, there is a precipitation of chloride of platinum and potassium, but no precipitation of platinum and ammonium; and that, on adding caustic potash to such urine, the precipitate under the microscope does not exhibit the well-known star-like groups of laminæ of basic phosphate of ammonia and magnesia, but merely amorphous matter; and further, that no ammonia can in this precipitate be chemically detected. Scherer and

Liebig deny the presence of ammonia in normal urine; and Heintz found that the ordinary urinary sediments consisted of urate of soda, with a little urate of lime and only traces of urate of ammonia. We have no difficulty as to the probable origin of the ammonia. If we carefully evaporate perfectly fresh urine in a retort, at the lowest possible temperature, the distillate will contain ammonia, while the concentrated urine has an acid reaction. In this case, the acid phosphate of soda exerts a decomposing action on the urea, or the pigment, or both, and phosphate of soda and ammonia is formed, which, at a temperature of 100 degrees, evolves ammonia, and is converted into acid phosphate of soda.

105. *The fixed salts of the urine* are so called from their being left after the other ingredients are destroyed by a red heat; they amount on an average to upwards of 138 grains in twenty-four hours. These consist, as has been shown (70), of combinations of chlorine, sulphuric and phosphoric acid with soda, lime, magnesia, and potass. Of these, the combinations of chlorine and phosphoric acid are probably entirely derived from the food.

To show how readily the supply of earthy phosphates may be thus obtained, I have calculated from the best authorities the quantities of these salts which exist in an ounce of eleven different articles of food. The numbers must not be assumed as rigidly correct, as in some of the analyses the sulphates and carbonates were included with the phosphates:

Articles of food.	Phosphates in 1 oz.	Authority.
	Grains.	
Peas (Pisum sativum) . . .	9·26	Braconnot.
Maise (Zea mays)	7·2	Gorham.
French bean (Phaseolus vulgaris) .	4·7	Braconnot.
Wheat (Triticum hybernum) .	4·7	Liebig.
Beans (Vicia faba)	4·7	Einhoff.
Potatoes (Solanum tuberosum) .	2·35	Liebig.
Rice (Oryza sativa) . . .	1·92	Braconnot.
Milk	1·2	Liebig.
Artichoke (Helianthus tuberosus) .	0·96	Payen and Braconnot.
Vetchling (Lathyrus tuberosus) .	0·756	" "
Beef	0·38	Liebig.

The salts found in the urine after the use of any particular kind of food may at once be known by referring to the composition of the ashes obtained by burning the substances entering into the food—the saline elements of the ashes and of the urine being always identical.

106. It is impossible to state with certainty in what manner, and with what bases, the phosphoric acid exists in the urine. Phosphate of soda and lime are certainly present, and in all probability the former possesses the chemical constitution of the common rhombic salt, or perhaps is combined with phosphate of ammonia, forming the double, or microcosmic salt. The phosphate of magnesia is also an element of healthy urine, as on the addition of ammonia a mixture of ammonio-phosphate of magnesia and phosphate of lime is precipitated. The following formulæ represent the atomic composition of those different salts. They are all tri-basic.

Phosphate of soda* . . .	$(HO, 2NaO, P_2O_5)+24HO$
Ammonio-phosphate of soda	$(HO, NH_4O, NaO, P_2O_5)+ 8HO$
Phosphate of lime . . .	$(HO, 2CaO, P_2O_5)$
Ammonio-phosphate of magnesia	$(NH_4O, 2MgO, P_2O_5)+12HO$

* Robin and Verdeil describe the two following salts as normal constituents of the urine—

107. The form in which the combinations of phosphoric acid with soda exist in the urine and other animal fluids has been frequently made the subject of discussion. The fact of the saline residue, obtained by igniting an extract of urine, being alkaline, whilst it often does not effervesce with acids, proves at once that the presence of an alkaline carbonate cannot account for its power of restoring the colour of reddened litmus. Enderlin has endeavoured to meet this difficulty, by assuming that phosphate of soda exists in the urine in the form of the alkaline tri-basic phosphate, or $3NaO, P_2, O_5$. Among other serious objections that may be urged against this view, I might adduce the fact, that no evidence exists of this particular phosphate occurring, except as the artificial product of manipulations in the laboratory. There is not a particle of evidence adduced of its really existing in the urine. Its existence, however, appears very necessary for the support of Liebig's view of the non-existence in the urine of any salt of an organic acid.

From a careful series of experiments, I have elsewhere shown[124] that a combination of an organic acid with an alkali may exist in a fluid containing the common or rhombic phosphate of soda ($HO, 2NaO, P_2, O_5$), and yet the residue of incineration may be free from an alkaline carbonate. This is easily explained, for during ignition, the organic acid is destroyed, and its base replaces the water in the phosphate, converting $HO, 2NaO, P_2, O_5$ into $3NaO, P_2, O_5$. I found that 9 grains of dry phosphate of soda, and 4 of dry acetate of soda, dissolved in water, evaporated to dryness and incinerated, yielded a mass of the alkaline tri-basic phosphate, which did not effervesce with acids, and was free from any carbonate.

Neutral phosphate of soda .	$(HO, 2NaO, P_2O_5)+26HO$
Acid phosphate of soda .	$(12HO, NaO, P_2O_5)+2HO)$

Hence I consider, that until better evidence is adduced, we must be content to regard the phosphoric acid and soda as existing in the state of the common rhombic phosphate unless it is combined with the phosphate of ammonia.

108. The soluble phosphates, which far exceed in quantity the insoluble salts, must be regarded as derived directly from the food, as well as from the albumen (111) and other elements of the blood when in the act of being organized into muscle. The insoluble phosphates forming part of the structure of the body, derived originally from the blood, are conveyed to the urine in the process of metamorphoses of tissues. Some portion of the phosphoric acid of the urine is in all probability generated from the action of oxygen on many of the structures of the body, into the composition of which phosphorus largely enters, as the brain and nervous system generally. But the greatest part of the phosphoric acid is, as we have seen, derived ready formed, from without, the phosphates of lime and magnesia abounding in milk and most varieties of vegetable food; whilst the basic alkaline phosphates exist in flesh, in wheaten flour, leguminous seeds, as beans and peas, &c.

109. Dr. B. Jones has made some very laborious and interesting researches on this subject, and he has shown that the quantity of phosphates in a given quantity of urine bears some relation to the periods of taking food, as well as the composition of the meals. Thus, in 1000 grains of urine, the earthy phosphates ranged before taking food from 0·21 to 0·75 grain, and after taking food from 0·97 to 1·91 grain; and in the same quantity of urine, the alkaline phosphates varied before food from 6·5 to 8·1 grains, and after food from 4·72 to 6·67 grains.

The quantity of phosphatic salts is also much greater after a diet restricted to vegetable than to animal food. Thus, after a person had been limited for three days to each of these forms of nourishment, the following were the results, the urine being examined in each case on the third day. On the third day of exclusively vegetable diet, 1000 grains of urine, at 6 p.m., contained 0·37 grain of earthy and 8·19 of alkaline phosphates; at 11 p.m., contained 1·86 grain of earthy and 3·56 of alkaline phosphates. On the third day of exclusive animal diet, the same quantity of urine, at 6 p.m., contained 0·42 grain of earthy and 4·04 of alkaline phosphates; at 11 p.m., contained 0·81 grain of earthy and 4·31 of alkaline phosphates. The quantity of phosphates of lime and magnesia in the urine are found to be considerably increased after the administration of soluble salts of these two earths. The alkaline phosphates are most abundant shortly after a meal composed chiefly of bread, and do not appear to be materially affected by the circumstances which influence the excretion of the earthy salts. The ashes of blood contain the basic alkaline phosphates; and muscle, when incinerated, yields much phosphate of lime and some phosphate of magnesia. The alkaline and earthy phosphates, in the opinion of Liebig, are chemically combined, the former with albumen, the latter with fibrine. During the formation of muscular tissue, whilst blood is becoming converted into muscle, the earthy phosphates remain in the new-formed tissue in a state of chemical combination; the greater amount of the phosphates of soda and potass re-enter the circulation, are separated by the kidneys, and thus find the way into the urine.

110. A part only of the earthy phosphates contained in the food is absorbed into the circulation, the greatest

proportion escaping by the intestines. Berzelius found in three ounces of human excrements six grains of earthy phosphates.

If a tolerably fluid fæcal evacuation of a person who partakes freely of farinaceous food is allowed to repose for a short time, after being mixed with a pint or two of water, and the greater part of the mixture decanted, a quantity of large crystals of triple phosphate of magnesia can easily be detected at the bottom of the vessel. These crystals are sometimes coloured grass-green from the presence of bili-verdin, or of modified colouring matters of blood.

The insolubility of the salts in water fully accounts for their abounding in the fæces, as the kidneys alone remove those substances not required for the reparation of tissues, which are readily soluble, according to Wohler's well-known law.[126] This is well shown by contrasting the result of Enderlin's analyses of the ashes of human blood and fæces.

	Ashes of blood.	*Ashes of fæces.*
Phosphates of soda (tribasic)	22·1	(bibasic) 2·633
Chloride of sodium	54·769	1·367
" potassium	4·416	
Sulphate of soda	2·461	
Earthy phosphates and oxide of iron	5·509	82·462
Sulphate of lime	...	4·530
Siliceous matter	...	7·940
	89·255	98·932

A small quantity of phosphorus also exists in the urine in a non-oxidized form. This fact may be easily demonstrated by comparing the quantity of phosphoric acid existing in the ashes of urine obtained by simple incineration, with that found in the ashes of the same

urine, after deflagrating its extract with nitre in a red-hot crucible. The excess of phosphoric acid thus found arises from the oxidation of the phosphorus of the urine.

111. The proportion of sulphuric acid present in the urine is too large to be entirely explained by its presence in the food in a state of saline combination. Indeed, an abundance of sulphuric acid may be detected in the urine, whilst food absolutely free from sulphates is taken into the stomach. The origin of this acid is rather to be traced to the oxidation of the sulphur which exists with phosphorus in the elements of those tissues which contain albumen and fibrin. These two substances consisting, according to Professor Mulder, of—

	Albumen.	*Fibrin.*
Carbon	54·84	54·56
Hydrogen	7·09	6·90
Nitrogen	15·83	15·72
Oxygen	21·33	22·13
Phosphorus	0·33	0·33
Sulphur	0·68	0·36
	100·1	100·

Thus, during the destructive assimilation or metamorphosis of tissue, oxidation of the sulphur occurs, and explains the presence of at least a portion of the sulphuric acid met with in the urine.

112. Since the discovery made by Professor Redtenbacher of the existence of nearly twenty-five per cent. of sulphur in taurine (one of the products of the metamorphosis of bile), a portion of the sulphuric acid of the urine may be regarded as resulting from the oxidation of the biliary sulphur. For it must be borne in mind that the bile is not separated from the portal blood by the liver as an entirely effete and useless product,

as it certainly in some form or other re-enters the circulation, and plays an important part in the animal economy, connected in all probability with the evolution of heat, prior to the final excretion of its elements. We have already seen that a portion of sulphur is eliminated from the system in a non-oxidized form in the urine (103). Hence a part only of the sulphur not required for the purposes of the animal economy undergoes oxidation. In five specimens of urine of healthy persons, Professor Ronalds found the proportion of sulphuric acid existing in one thousands grains to bear to the non-oxidized sulphur the following proportions:

1·06 : 0·17—1·46 : 0·18—1·42 : 0·18—2·44 : 0·153—
1·32 : 0·165.

113. We are indebted to Dr. B. Jones for some interesting observations on the quantity of sulphuric acid in the urine under different circumstances. From his researches, it appears that the salts of this acid are increased in the urine by food of any kind, whether animal or vegetable. Exercise does not appear to increase them, though, from some carefully instituted experiments, Gruner concludes that extraordinary exertion and mental excitement appear to augment the excretion of the acid. The administration of sulphuric acid, except in very large quantities, has no effect on its production; but the administration of sulphur, or of sulphates of soda or magnesia, always augments the quantity of sulphuric salts in the urine.

The sulphuric acid existing in combination in the urine is best determined by ascertaining the quantity of sulphate of baryta precipitated on the addition of chloride of barium to the urine, after acidifying it with

hydrochloric acid. Dr. B. Jones met with the following results:

Urine secreted between	1 and 3 p.m.	yielded from	1000 grains	7·70	grains of sulphate of baryta,
"	3 and 6	"	"	7·93	
"	9 and 11	"	"	11·85	

breakfast having been taken at 9 a.m. and dinner at 6½ p.m.

Before food, 1000 grains of urine yielded a precipitate of sulphate of baryta, varying from 7·07 to 8·56 grains, the same quantity after food affording from 9·49 to 15·23 grains. After the administration of sulphate of magnesia, 1000 grains of urine has yielded as much as 22·55 grains of sulphate of baryta.

Dr. Parkes has considerably added to our knowledge on this subject; and his papers are well deserving of careful study.

114. The chloride of sodium of the urine is probably derived immediately from the common salt which forms so important a constituent of our food.

Some of the saline combinations existing in the urine can be readily recognised by the crystalline forms they present when obtained by simple evaporation on a glass plate (13).

115. M. Barral, in a paper presented to the French Academy, has adduced evidence in favour of a probable function performed by the chloride of sodium; having announced that it always increased the elimination of nitrogenized compounds in the urine. His experiments were chiefly performed on sheep, and he found that the daily administration of 185 grains of chloride of sodium produced a much increased excretion of nitrogen, as indicated by the increase of urea and the nitrogenized compounds. Similar views had previously been announced

by MM. Regnault and Reiset. It would here appear probable that common salt, for which so universal an appetite exists, besides furnishing hydrochloric acid to the stomach, and soda to the bile, also exerts an important physiological influence in aiding the metamorphosis of tissue, and consequent depuration of the blood.

Hegar, whose investigations were conducted under the superintendence of Liebig and Vogel, found from experiments on eight men, whose ages in the instance of seven ranged from twenty to twenty-five, while the eighth was thirty-eight, that the mean quantity of chlorine in the urine of twenty-four hours was 161·397 grains, the maximum being 214·78 grains, and the minimum 113·33 grains.

The following are the most important conclusions at which he arrived: 1. The amount varied in different individuals, depending partly on the food and partly on habit of life and constitution. 2. It had no definite relation to the weight or height of the individual. 3. It attained its maximum in the afternoon, although not immediately after dinner, fell to its minimum in the night, and rose again in the morning. 4. It was increased by exercise and copious draughts of water, which appeared to act by washing it out of the system, as the augmentation was only temporary. 5. Indisposition diminished the quantity. 6. In health, though no chlorides were taken with the food, they were always found, and must therefore have been obtained from the blood or tissues. 7. When a larger quantity was taken than usual, the whole did not escape from the system by the kidneys, nor even the bowels. 8. The relation which the excretion of chlorine bore to urea and uric acid, and its connection with respiration, were not known. The quantities of the chloride can be calculated from Bischoff's table given above. The

chlorides are diminished in all cases of disease accompanied by copious exudation from the blood.*

116. Dr. Redtenbacher some time ago stated that chloride of sodium was invariably absent from the urine passed by patients labouring under pneumonia. This remark would appear at first sight to receive a probable explanation from the altered diet of patients labouring under acute disease. Dr. Lionel Beale has, however, shown that this explanation is insufficient, and he has, in a very elaborate paper read before the Royal Medical and Chirurgical Society, established the following very interesting propositions:

1. That chloride of sodium is totally absent from the urine of pneumonic patients at the period of complete hepatization of the lung.

2. The chloride re-appears after the resolution of the inflammation.

3. The chloride exists in the blood in the largest quantity when most abundant in the urine, and *vice versâ*.

4. The chloride exists in very large quantity in the sputa of pneumonic patients.

5. There is reason to believe that in pneumonia the chloride is determined towards the inflamed lung, and is re-absorbed and removed on the resolution of the inflammation.

In acute rheumatism, capillary bronchitis, and typhus, as well as pneumonia, the chlorides are diminished. Dr. Hughes Bennett has furnished some useful matter on this subject.

Formation of deposits or sediments.

117. Whenever the different constituents of the urine

* Dr. Day's 'Contributions to Urology.'

maintain their proper relation to each other, the fluid, as it leaves the urethra, is clear and of a pale amber colour, its transparency being but slightly affected on cooling by the gradual subsidence of a slight mucous cloud, occasionally entangling in its meshes a very few microscopic crystals of uric acid. Whenever, however, one or other of the ingredients exist in real or comparative excess, or a new substance is superadded, the urine does not generally remain clear, but either immediately on being voided, or at least on cooling, becomes more or less turbid. Different names have been applied to the different degrees and states of turbidity, viz., pellicle, cloud, eneorema, and sediment, the hypostasis of the ancients.

When the urine, on cooling, becomes covered with a thin membrane-like scum, a *pellicle* is said to exist; when the substance producing the opacity floats in detached portions near the surface, it is said to form a *cloud*, and when this falls towards the base of the vessel, it was formerly termed an *eneorema*, a title now forgotten; the term *sediment* or hypostasis being applied to a deposit collected at the bottom of the vessel. Of these, the terms pellicle, cloud, and sediment, or deposit, are still retained as general terms, but are not now used for the purpose of distinguishing any real or imaginary pathological condition. It very frequently happens that deposits do not become visible in the urine until after it has cooled down to the temperature of the air; this is particularly the case with those which are soluble in warm water, as the urates, more especially those which constitute the great bulk of the red and fawn-coloured amorphous sediments. A crystalline deposit may escape detection by fixing itself in translucent crystals on the sides of the vessel, as sometimes happens with pale uric acid and triple phosphate. It is quite possible also for a

crystalline substance to be present in large quantity, and yet, on account of the minuteness of the crystals and their refractive power not greatly differing from that of urine, to remain unnoticed. This is remarkably the case with oxalate of lime, and such deposits are best detected by gently warming the urine, and, after a few moments' repose, pouring off the greater part of the fluid; on replacing this with distilled water, the previously overlooked deposit will become visible.*

118. Urinary deposits, including under this term all substances which disturb the transparency of urine by their presence, whether they subside to the bottom of the vessel or not, may be conveniently divided into the four following classes:

Class 1.—Deposits composed essentially of ingredients formed directly or indirectly from the metamorphosis of tissues, or from the organic elements of food, capable of assuming a crystalline form.

Uric acid and urates.
Uric oxide.
Oxalate of lime.
Oxalurate (?) of lime.
Cystine.

Class 2.—Deposits composed of ingredients for the most part of inorganic origin; including—

Phosphate of lime.

* I have never applied heat with this view, as Dr. Owen Rees contends that by gentle heat the oxalate is formed as a result of a rearrangement of the elements of urea, especially where the urates are in excess; and not merely deposited from its greater weight in the warmed urine. The question is still *sub judice*, but to avoid every possibility of error, we must not be satisfied unless we find the oxalate in *fresh* urine, and without the aid of heat; but I shall have to consider this subject hereafter.

Acid phosphate of lime.
Ammonio-phosphate of magnesia.
Carbonate of lime.
Neutral phosphate of soda.
Acid phosphate of soda.
Silicic acid.

Class 3.—Highly coloured deposits (black or blue) of doubtful origin.

Cyanourine.
Melanourine.
Indigo.
Prussian blue.

Class 4.—Deposits consisting of non-crystalline organic products; including—

A. *Organized.*
Blood.
Pus.
Mucus.
Organic globules.
Epithelium.
Renal Casts.
Spermatozoa.
Confervoid bodies.
Vibriones.

B. *Non-organized.*
Milk.
Fatty matter.
Stearolith.

CHAPTER IV.

CHEMICAL PATHOLOGY OF URIC ACID AND ITS COMBINATIONS.

(*Lithi-uria.*)

Colour of uric acid deposits, 119—Diagnosis of, 120—Characters of the urine, 122—Microscopic characters of the deposits, 124—Cause of variation, 126—Pisiform deposits, 129—Diagnosis of urates, 136—Character of urine, 131—Microscopic characters of the deposit, 133—Urate of soda, 135—Pathological changes in quantity of uric acid, excess, 136—in the blood, 137—Deficiency, 138—Influence of perspiration, 139—Erasmus Wilson's observations, 140—Seguin's experiments, 141—Liebig's theory, 143—Becquerel's researches, 144—Causes of excess of uric acid, 146—Detection of, 147—Excess traced to ingesta, 148—Conditions for separation of the free acid, 149—Uric deposits considered as calculous affections, 152—Therapeutical indications, by diaphoretics, 153—by correcting the digestive functions, 155—by iron, 158—by solvents, alkalies, 160—Vichy water, 161—Alkaline salts, 162—Biborate of soda, 164—Phosphate of soda and ammonia, 165—Benzoic acids, 167—Use of solvents, "Constitution" water, 170.

119. When uric acid exists in an urinary deposit, uncombined with a base, it is invariably in a crystalline form, never occurring in the state of an impalpable amorphous powder. The crystals are seldom sufficiently large to allow their figure to be defined without the aid of the microscope; sometimes being so minute, that the deposit has been mistaken for urates, or even for mucus, until microscopic examination has discovered the error.

Uric acid never occurs quite colourless; indeed, excepting when mixed with the urates, which is frequently the case, it presents a characteristic yellow or amber colour. Every shade of intensity of tint, from the palest fawn-colour to the deepest amber or orange-red, may be often observed in these deposits; and hence the terms yellow or red sand are applied to them. In general, the deeper the colour of the urine, the darker the sediments.

120. *Diagnosis of uric acid deposits.*—When heated in the urine, the uric acid deposit does not dissolve; the crystals merely become opaque. They generally become more distinct from the solution of the urates, which are frequently mixed with them, and sometimes completely conceal them from view. Hence the best mode of discovering this deposit, is to warm the urine, when turbid from excess of urates in a watch-glass; the acid becomes visible at the bottom of the glass, as soon as the urates dissolve. Heated with liquor potassæ, the uric acid deposit dissolves, from the formation of urate of potass of ready solubility in the alkaline fluid. Hydrochloric and acetic acids are without any action, but the nitric readily dissolves it, and by careful evaporation a residue of a beautiful pink colour, becoming of a rich purple on being held over the vapour of ammonia, is left. This coloured residue is the murexid of Liebig, the purpurate of ammonia of Dr. Prout. Exposed to heat in a platinum spoon, the uric acid deposits readily burn, evolving an odour of bitter almonds; and finally leave a small quantity of a white ash, which generally contains phosphate of soda or lime, or both.

121. *Characters of urine depositing uric acid.*—When urine contains an excess of this acid, it generally lets fall crystals on cooling, uric acid being very seldom deposited before emission. Sometimes many hours elapse before

any becomes deposited, even when a comparatively large quantity is present; this is often the case in the urine of gouty people. Occasionally, indeed, the acid is not deposited at all, but remains on the surface as a crystalline pellicle, presenting an iridescent play of colours when placed in a bright light. Urine depositing uric acid usually possesses a deeper amber tint than natural, sometimes being of a reddish-brown colour. Very high-coloured urine, however, seldom deposits uric acid until after the addition of a stronger acid. Urine never lets fall spontaneously all its uric acid as a deposit, until decomposition has commenced, for after being filtered from a sediment of this substance, the addition of a drop of nitric acid generally causes the deposition of an abundance of crystals of uric acid in a few hours.

Urine depositing uric acid always reddens litmus paper, and often contains an excess of urea, so as to crystallize slowly when mixed with nitric acid in a watch-glass (72). Its specific gravity is generally above 1·020. An exception to the above character is presented by the pale urine of infants at the breast, among whom deposits of uric acid are common. These often appear as a yellow crystalline sand, whilst the supernatant urine is frequently of low specific gravity, often 1·006, as pale as water, and containing very little urea. This circumstance admits of explanation from the small proportion in which the alkaline phosphates, the presumed solvent for uric acid, exists in the urine of infants.

122. *Microscopic characters.*—The varieties presented by uric acid in its crystalline form are very remarkable; all of them, however, may be traced to some modification of the rhombic prism, which may be assumed as the normal crystalline form of this substance. But two varieties can be artificially obtained, by filtering a warm solution

of urate of potass or ammonia, into dilute and warm hydrochloric acid; either perfect rhomboids, or square tables, generally excavated at the sides into an imperfect hour-glass figure, being obtained. The latter have been erroneously described, both in this country and in America, as identical with the dumb-bell deposits of oxalate of lime, to which they have no analogy whatever, except in a distant resemblance in form. These varieties cannot always be produced at will, and appear to depend upon the strength of the solution of the urate employed, and temperature of the dilute acid. Examined with polarized light, the transparent crystals of uric acid exhibit a beautiful series of coloured bands, particularly with slowly precipitated specimens; their brilliancy of tint is only equalled by that of the scales of the diamond beetle.

Fig. 16.

123. The crystalline forms of urinary deposits can be examined by merely placing a drop of the turbid urine on a plate of glass, and examining it with a microscope under a good half-inch achromatic object-glass. By far the most satisfactory mode is, however, the following— which, by rendering the crystals distinct, amply repays the trouble it requires. Allow the urine to repose for a short time in a tall vessel, decant the greater proportion, and pour a tea-spoonful of the lowest turbid layer into a watch-glass, gently warming it to dissolve the urates, and to aid the deposit. Remove the supernatant urine with a pipette, and replace it with a few drops of water; then place the watch-glass under the microscope, and the crystals covered by the water will become most

beautifully distinct. Dr. Venables has suggested a mode of collecting the crystalline urinary deposits for examination which is exceedingly convenient, and economises the time required for the above process. This is founded on the tendency of these bodies to cohere on the cork of the bottle containing the urine. For this purpose the bottle should be inverted for a few minutes, then quickly erected, and the cork being withdrawn, the drop of fluid adhering to it should be transferred to a piece of glass. On gently covering this with a piece of mica, or thin glass, the crystalline form of the deposit can be readily recognised under the microscope.

All crystalline deposits may be examined by transmitted or reflected light, the latter having some advantages when the crystals are large or in masses. All that is then required is to place on the stage of the microscope, and under the watch-glass, a piece of black velvet; by means of a condensing lens, let a strong light be thrown upon the crystals; then bring the object-glass into proper adjustment, and the colour, as well as the figure of the crystals, will become beautifully defined on a black ground. In the following microscopic views, most of the larger crystals are thus represented.

124. In fig. 17 are represented the common rhomboidal crystals of uric acid; these are sometimes found so thin, as to be merely pale, lozenge-shaped laminæ; more generally, however, they are thicker, and then by adjusting the light carefully their sides and true figure become well marked. Many of them appear nucleated, from the presence of certain internal markings, as if one crystal included another. It seldom happens that the angles of these are sharply defined, the two obtuse corners being most generally rounded off; and sometimes the acute angles are blunted, so that the whole crystal

Fig. 17.

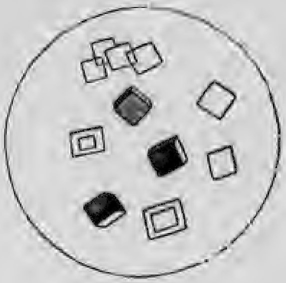

Fig. 18.

appears elliptical. The most perfect specimens of these are found in deposits of yellow sand in the urine of young infants; I have never seen them in red sand, or in deposits produced artificially by the addition of a mineral acid to urine. When the deposit has been of long continuance, especially in cases of calculous disease, the rhomboidal outline of the crystal is replaced by a square one (fig. 18). The deposit is then generally high-coloured, and the crystals much thicker than in the former variety. In these an internal marking, like a framework, is visible. Several accidental varieties of these rhomboid and square crystals exist; of these the most curious present a spindle-like figure, the obtuse edges being rounded, and the margin on either side excavated (fig. 19), so as sometimes to approach a fleur-de-lys outline. Many uric deposits appear at first sight to be made up of flattened cylinders, presenting a very remarkable appearance (fig. 20). Upon making them roll over, by adding a few drops of alcohol, or by agitation, the fallacy will be detected, and the supposed cylinders will be found to be really very thick lozenges lying on their sides. This variety is often found mixed with the urates and oxalate of lime; and is frequently

Fig. 19.

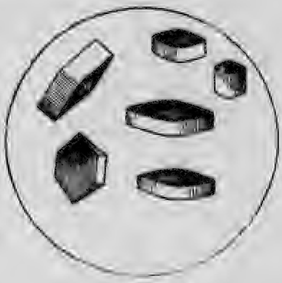

Fig. 20.

observed in the deposit produced by the addition of hydrochloric acid to urine.

125. The crystals are sometimes found to be very thin, and longer than broad, so as to represent square tables. These in general have their surfaces quite smooth, especially when they occur in pale neutral urine. When, however, they are met with in very acid urine, or are precipitated by the addition of nitric acid, the sides of the table are strongly defined, but the extremities are closely serrated, as if made up of a number of closely packed, irregular needles, crystallized on the body of the crystal. The whole surface is sometimes marked with myriads of close dark lines. When carefully examined, their bodies present a very remarkable internal marking, like two crescents placed with their convexities opposed (fig. 21). This curious appearance is only visible in the non-striated body of the crystal, and is most clearly seen after they have been dried and preserved in Canada balsam.

The cause of this very remarkable appearance is not very obvious. I am, however, convinced that these crystals are compound. Dr. Burton, of Walsall, who has worked at this subject with great zeal, informs me

Fig. 21.

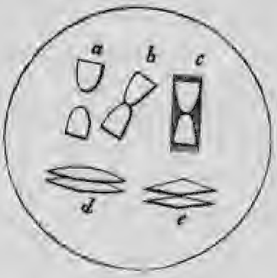

Fig. 22.

that he regards them as being made up of two rhomboidal crystals, with their apices approximated, and then become covered up with an aggregation of acicular crystals, as shown in *a, b, c* (fig. 22), where these several stages of formation are represented. I have fancied that by breaking these crystals by pressure, there was evidence of their really being formed by a couple of acute rhombs, superposed laterally, as shown in section *d, e*. When such crystals are immersed in a fluid as water, or Canada balsam, it will enter between the crystals by capillary attraction, and exhibit two curved outlines where the crystals approximate most closely, as in the well-known experiment of allowing water to ascend between two glass plates slightly separated at one end. I am induced to adopt this opinion, as I have never seen these curved markings except in crystals immersed in fluid or preserved in balsam.

126. A curious question arises as to the cause of these variations in the crystalline form of uric acid, for although they are all traceable to recognised variations of the primary rhomboidal crystal, still there must exist some recognisable cause of these varieties. Dr. Burton has communicated to me some interesting remarks on this

subject, and he seems to have a strong impression that variation in the composition of the urine modifies the form of the crystal, and hence a knowledge of the crystallized form of a deposit may possibly indicate the condition of the secretion, and consequently of the morbid state developing the lesion of function which exists. This very ingenious idea deserves a careful examination.

Dr. Schmidt, of Dorpat, has thrown much light on this subject, in a little essay on the *genesis* of uric acid, and he has shown that variations in the rapidity and manner of the precipitation will curiously modify the results. He found that when a drop of a solution of urate of soda is placed on a plate of glass with a drop of strong acetic acid, the following results were seen: At the moment of contact, a deposit of excessively minute globules (A) appears, often presenting the molecular movements described by Mr. R. Brown. The globules at last cohere into oval masses (B), which ultimately become transparent (C), and subsequently assume the form of hexagonal tables (D), or vertical prisms.

Fig. 23.

If a drop of a concentrated solution of urate of soda be heated to boiling, and an excess of acetic acid added, it will remain clear at first, but soon after will begin to deposit crystals of uric acid in rectangular columns and tables (E), more rarely in pseudo-morphous forms, made up of an aggregation of parallelopipedons. If the solution be not heated so strongly before the acetic acid is added, rhombic prisms are formed (F), and when the solution is still cooler even these become modified in figure (G). If a drop of the

mixture of solution of urate of soda and acetic acid be placed whilst boiling hot on a plate of glass, and be suddenly cooled by touching it with a glass rod, rhombic prisms are rapidly deposited, and grow up to a certain point, when on a sudden they become opaque, and split into minute rectangular parallelopipedons.

127. Coarse, and deep orange or red, sand is generally composed of cohering crystals, forming, indeed, minute calculi. Two varieties of these are frequently met with, one formed (fig. 24) of cohering, thick, rhomboidal prisms, and the other of aggregated lozenges in

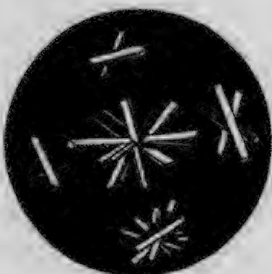

Fig. 24.

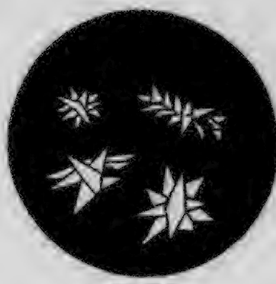

Fig. 25.

spinous masses. The latter are most frequently found where a marked tendency to the formation of calculi exists (fig. 25). It is not unfrequent to find these masses crystallized on a hair, just as sugar-candy is crystallized on a string or thread. When very hastily deposited by the sudden cooling of the urine, or by the addition of a strong acid, uric acid is sometimes precipitated in irregular masses, resembling on microscopic inspection irregular fragments of yellow quartz; this, however, is unfrequent, and is the only exception I am acquainted with to uric acid occurring in well-defined

crystals. More rarely we meet with aggregated masses of thick lozenges (124) of uric acid, presenting a very beautiful appearance, as shown (fig. 26) from a drawing given me by Dr. Burton.

Fig. 26.

All the forms of coarse uric acid gravel, on digestion in liquor potassæ in the cold, dissolve nearly entirely, the insoluble residue consisting of flakes of mucus, and very frequently minute crystals of oxalate of lime.

128. In examining some specimens of urine, in which I had reason to suspect the presence of uric acid, I have occasionally met with a remarkable variety resembling, to the naked eye, slender fibres of hairs about the eighth of an inch in length. These, on microscopic examination, were found to consist of numerous very minute lozenges cohering in linear masses (fig. 27), from having crystallized on a fibrinous cast (319) of a uriniferous tubule.

Fig. 27.

129. Another variety of uric acid deposit is exceedingly common in gouty persons, it occurs in little spherical masses of a pale yellow colour, varying in size from that of small millet seeds to that of a large pea, which ought indeed to be referred to the class of calculi rather than of deposits.

This *pisiform deposit* is remarkable for its persistance often during many years; it frequently vanishes for many months, and then re-appears. I have generally

observed the patient to remain free from gout during the presence of this deposit, and often to suffer from a severe paroxysm on its sudden disappearance. It is really remarkable what an enormous number of these minute calculi are frequently passed. I have met with cases in which upwards of two hundred, the size and colour of small mustard seeds, have been passed in two days.

These pisiform concretions, after a few minutes' digestion in weak nitric acid, undergo a curious change, their crystalline structure becoming visible, presenting the appearance of numerous acute rhomboids, diverging from a common centre. It is evident that they, at their first formation, possess this form, the rounded smooth surface being subsequently produced by the deposition of minute crystals of uric acid or the urates between the projecting angles.

The three representations in the accompanying figure give three other forms assumed by uric acid; *a* is the dumb-bell crystal; *b*, a fusiform; and *c* appears to be a

Fig. 28.

duplicated variety of that form of crystal which has been, in a previous page (fig. 19), compared in outline to a fleur-de-lys.

130. *Diagnosis of deposits of the urates.*—These deposits vary in colour, from absolute whiteness, through almost every variety of tint, to a pale fawn-colour (the most frequently met with), brick-red, pink, or purple. All these various-coloured deposits present certain characters in common; they never appear in the urine until after it has cooled, and disappear with the greatest readiness on the application of heat. The purple deposits require rather a higher temperature for solution than the paler varieties, and sometimes, on account of the concentration of the urine, the addition of a little water is necessary before they quite disappear. The addition of liquor ammoniæ, or liquor potassæ, immediately dissolves these deposits, but at the same time renders the urine a little turbid from the precipitate of the earthy phosphates.

131. *Characters of urine depositing the urates.*—The following modifications are most important:

1st. A pale urine of low specific gravity (1·012), becoming opaque on cooling from the deposition of nearly white urates, which, instead of readily falling, form rope-like masses in the fluid, and present, on a superficial view, so much the appearance of muco-pus, as to have been mistaken for it. Their disappearance on the application of heat will at once discover their real nature.

2d. A pale amber-coloured urine of moderate density (1·018), which, on cooling, lets fall a copious fawn-coloured deposit, resembling bath-brick grated into the urine, disappearing with the utmost readiness on applying a gentle heat. This deposit is of frequent occurrence, often very transient, and is so constantly an attendant on the slightest interference with the cutaneous transpiration, that a

"cold" is popularly diagnosticated whenever this state of things exists.

3d. Whenever febrile excitement prevails, the urine becomes concentrated, rises in density (1·025), and deposits on cooling a reddish-brown sediment, constituting the well-known lateritious, or brick-dust sediment. This variety of urine generally becomes turbid on the addition of a drop of nitric acid, not from the coagulation of albumen, as has been frequently but erroneously supposed, but from the precipitation of uric acid in minute microscopic rhomboidal crystals, notwithstanding the amorphous appearance they present to the naked eye.

4th. In all cases where there exists great obstruction to the elimination of carbon, as in well-marked affections of the portal circulation, especially when connected with organic disease of the liver or spleen, or less frequently when suppuration, particularly of a strumous character, is going on in the body, the urine is generally found to possess, in many instances, a deep purple or copper colour, often verging on crimson, so as to have led to the idea of blood being present. These deep tints appear to me to depend upon the presence of an excess of purpurine (180). Whenever a deposit of the urates occurs in such urine, either spontaneously or by immersing it in a freezing mixture, it combines with the pink pigment, forming a kind of *lake*, and which is often so abundant as not to entirely disappear by heat, until the urine is diluted by the addition of water. These deposits do not exhibit their delicate tints until after being collected in a filter; they readily give up their colouring matter to alcohol, which scarcely acts on the urates they contain.

132. It has been shown by Dr. B. Jones, that the quantity of the urates really existing in the urine is not

always indicated by the amount of the deposit, for if the urine is less acid than usual, it will hold dissolved much more of these salts than when of average acidity. On the other hand, very acid urine will cause a deposition of the urates when but a moderate proportion of this body is present.

133. *Microscopic characters of the urates.*—When a drop of urine, turbid from the presence of this substance, is placed between two pieces of glass, and examined with the microscope, a mere amorphous precipitate is first seen. On minute examination this will be found to be composed of myriads of excessively minute globules adhering together, forming little linear masses (fig. 29), often mixed with crystals of uric acid. Sometimes, especially if the urine has been long kept, the minute particles cohere and form small opaque spherical bodies, appearing black by transmitted light, on account of their opacity; when examined by reflected light, on a black ground, they present a buff or fawn-colour. On the application of a slight heat to the drop of urine, the particles of the urates disappear, again becoming visible on cooling. An elegant mode of showing the composition of the deposit, is to place a drop of the turbid urine in a watch-glass, and gently warm it; as soon as it has become clear, add a drop of almost any acid (the hydrochloric is perhaps the best), and as soon as it has become cold examine it with the microscope. The muddiness previously produced by the urate will have

Fig. 29.

become replaced by lozenges of uric acid (fig. 13). The urate of ammonia* occurs very rarely in spherules with crystals of uric acid adhering to their surface; this is occasionally observed in albuminous urine, occurring in dropsy after scarlatina (fig. 30), and from its opacity is best observed by reflected light.

Fig. 30.

Fig. 32.

134. It has been stated, especially by Continental observers, that urate of ammonia occurs in deposits in

* These crystals are believed to be urate of soda. Fig. 31 gives other

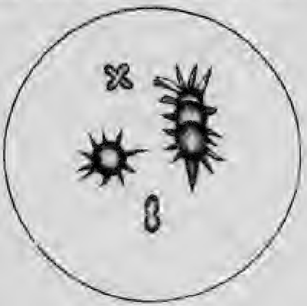

Fig. 31.

varieties of spherical masses, either single or united, surrounded by spicules, and also of the dumb-bell form, which is not so frequently met with.

delicate needles, sometimes united so as to form stellæ. I have never seen this variety in urine. Fig. 32 shows the minute needles and stellæ of urate of ammonia, artificially prepared by dissolving uric acid in a warm solution of ammonio-phosphate of soda, and allowing the crystals to separate by repose (79). It is difficult to imagine this form ever occurring in urine, as Dr. B. Jones has shown that the presence of saline matter, or of the colouring matter of urine, interferes with the needle-like crystallization of urate of ammonia, and converts it into minute globular particles. Urate of ammonia is abundant in the urinary excretion of birds and reptiles, forming nearly white spongy masses. It then generally appears in the form of oval or roundish bodies, exhibiting something approaching to a radiated structure. Fig. 33 shows a specimen from the urine of the pigeon, from a drawing by Dr. Garrod.

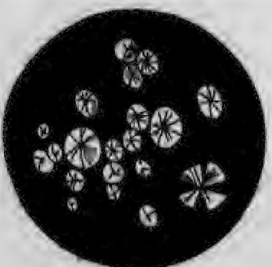

Fig. 33.

135. Of the other salts of uric acid, the urate of soda is the only one I have satisfactorily recognised, forming a distinct deposit. It occurs occasionally in gout, but I have more generally met with it in the urine of persons labouring under fever, who were treated with carbonate of soda. It then occurs in round yellowish or white opaque masses, provided with projecting, generally curved processes, forming a very remarkable figure (fig. 34). Varieties of this, more confusedly crystalline, are less unfrequent. When artificially prepared, by dissolving uric acid in a hot solution of carbonate or phosphate of soda, it appears in two forms, depending upon the mode

of preparation. If allowed to separate on cooling from the solution, the urate of soda crystallizes in needles and

Fig. 34.

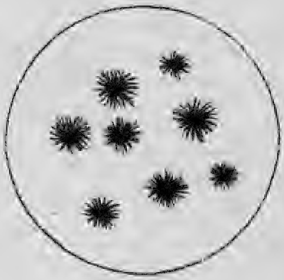

Fig. 35.

tufts (fig. 35); but if a solution of it be allowed to evaporate spontaneously on a glass plate, it assumes the form of spherical masses like minute pearls.

136. *Pathological changes in the quantity of uric acid and its bases.*—Independently of an alteration in the proportion of uric acid by an excess or deficiency of nitrogen in the food (84), certain pathological states of the system exert a most important influence on the quantity excreted. We have seen that uric acid may be traced to two great sources, viz., the disintegration of tissues, and to nitrogenized food (89). It is obvious, therefore, that whatever increases the rapidity of the former process, or interferes with the due digestion or assimilation of the latter, will materially affect the amount of uric acid contained in the urine. Experience has shown that in all diseases attended with great emaciation, when the wear and tear of the frame is not compensated by the supply of food, an increased quantity of uric acid appears in the urine, if the kidneys remain sufficiently healthy to perform their functions. But certain exceptions are presented to this

general rule, in cases where the renal function is itself impaired, as in granular disease of the kidney (Morbus Brightii). In all acute inflammatory diseases, in acute inflammation supervening upon chronic mischief, in rheumatitis, in organic, or even sometimes functional affections of organs materially influencing the circulation, as the heart, liver, and perhaps the spleen, a considerable increase in the quantity of uric acid will occur, and deposits of this substance, either free or combined, will appear in the urine. Taking the average of eleven cases of acute inflammatory diseases, reported by M. Becquerel, and twelve of continued fever (on the fifteenth day), by M. L'Heritier, we find that the quantity of uric acid was more than double the healthy average.

	Acute inflammation.	*Fever.*	*Health.*
Specific gravity of the urine .	1·0216 .	1·0229 .	1·017
Uric acid	1·041 .	1·312 .	0·391

In the two allied affections, gout and rheumatism, exclusive of the many neuralgic diseases popularly referred to the latter, a remarkable tendency to the formation of an excess of uric acid, both pure and combined, occurs. The elements of the acid, or its combinations, are in these diseases supplied by the nitrogenized elements of the food, as well as by the changing tissues of the body. In such quantities is urate of soda often generated, that the watery portions of the blood are not sufficient for its solution; and part of it is deposited in the joints and sheaths of the tendons, producing painful swellings.

137. Dr. Garrod[150] has indeed succeeding in discovering urate of soda in the blood of gouty patients, and by the following process any one may satisfy themselves of this very important fact. Collect the serum of blood of a

gouty patient, evaporate it to dryness over a water-bath, and reduce the dry mass to powder. Digest this with water of the temperature of 100° for an hour. Urate of soda with other matters will be dissolved out, and on evaporating the solution to a small bulk, and adding a little strong acetic acid, acetate of soda will be formed, and crystals of uric acid deposited after a few hours. They are more readily obtained if a few fibres of flax or tow are placed in the fluid, as they then crystallize upon these bodies like sugar-candy on a string. Dr. Garrod found that, on first removing the fatty matter from the dried serum of blood by digestion in alcohol, and exhausting the insoluble residue by boiling water, the concentrated decoction by repose became covered with a pellicle of crystals of urate of soda (fig. 36). He has produced evidence to show that whilst uric acid always exists in the blood both in acute and chronic gout, it is very deficient in the urine. In the acute form of the disease, the uric acid becomes remarkably diminished in the urine immediately before the gouty paroxysm, obviously pointing out its accumulation in the blood.

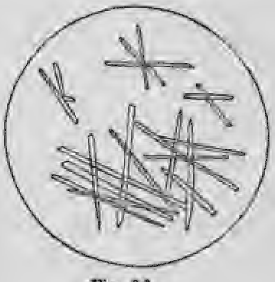

Fig. 36.

138. In all diseases attended with excessive debility, independently of acute disease, especially where an anæmic or chlorotic state exists, and when the circulation is languid, or, if excited, the excitement is owing to irritation rather than inflammation, a deficiency of uric acid occurs, and no deposits ever take place in the urine, unless the quantity of water present be remarkably diminished. The dimi-

nution of uric acid is well observed after losses of blood, in chlorosis, and in many neuralgic and hysteric affections. The average drawn from four cases of chlorosis, observed by Becquerel, and one of melæna, another of irritable uterus, and a third of spermatorrhœa, examined by myself, is as follows:

Average density . . .	1·015
Water	976·0
Uric acid	·184

The quantity of uric acid being less than one half the normal proportion.

139. As a general rule, whenever the functions of the skin are impaired, where a due amount of secretion is not exhaled from the surface, an excess of nitrogen is retained in the blood, and ultimately separated by the kidney in the form of urates, or perhaps urea, or creatinine, which substances contain respectively 38, 46, and 37 per cent. of this element. A person in apparently good health, experiences, from exposure to a current of cold air, a slight check to perspiration, and the next time he empties his bladder he voids urine of a deeper colour than is usual with him, and on cooling it becomes turbid from the precipitation of the urates. The explanation of this phenomenon, with which every one is familiar, is found in the kidneys assuming temporarily a kind of compensating function for the skin. It is true that uric acid, or the urates, are not naturally expelled from the surface of the body, but certain organic matters, rich in nitrogen, certainly are; and if their proper emunctory, the skin, has for a time its function arrested, they are probably filtered from the circulating mass by the kidneys, in the form of urates. That nitrogenized products are exhaled

from the skin is indubitable. Dr. Faraday calcined pure river sand, and on heating it with hydrate of potass, it yielded no trace of ammonia. On merely passing this sand over his hand, and then treating it in a similar manner, ammonia was evolved. A piece of ignited asbestos, by mere pressure for a short time between the fingers, absorbed enough of some nitrogenized organic matter to evolve ammonia when heated with hydrated potass.

I have two or three times been consulted in the cases of patients lying bed-ridden from rheumatic gout, in whom one or both legs were covered with an eczematous eruption, and the parts on which the exudation from the surface had dried have been actually frosted with microscopic crystals of urate of soda.

Although my observations have not been sufficiently extended to warrant its announcement as a general law, I may state that in cases of lepra, psoriasis, and icthyosis, where the excreting functions of the skin have been much impaired, the urine has been much richer in urea than was consistent with health.

140. It is quite certain that the value and importance of the functions of the perspiratory system, in relation to those of the other depurating organs, have not been sufficiently estimated. The following observations of Mr. Erasmus Wilson[126] on this subject are exceedingly striking and interesting: "I counted the perspiratory pores in the palm of the hand, and found 3528 in a square inch; now each of these pores being the aperture of a little tube of about a quarter of an inch long, it follows that in a square inch of skin on the palm of the hand, there exists a length of tube equal to 882 inches or 73·5 feet. Surely such an amount of *drainage* as 73 feet in every square inch of skin, assuming this to be the

average of the whole body, is something wonderful, and the thought naturally intrudes itself,—What if this *drainage* were obstructed?"——"The number of square inches of surface in a man of ordinary height and bulk is about 2500; the number of pores, therefore, is 8,820,000, and the number of inches of perspiratory tube 2,205,000, that is 183,750 feet, or 61,250 yards, or nearly 34 miles."

141. From a series of careful observations, Seguin[38] ascertained that, on an average, eleven grains of matter were exhaled from the skin in a minute, equal to 15,840 grains, or 33 ounces, in 24 hours. Consequently, the amount of perspired matter very nearly equals that of the urine. The exhaled fluid was afterwards examined by Anselmino,[39] who found that it contained on an average 0·88 per cent. of solids; and 100 grains of this solid extract contained 22·9 grains of saline matter. Hence in the course of 24 hours the skin exhales—

Organic matter . . .	107·47 grains.
Saline matter . . .	81·92
Water and volatile matter . .	15650·61
	15840·

This organic matter contains much nitrogen, and I have more than once detected in it a body resembling, if not identical with, urea, an observation confirmed by the researches of Landerer. Berzelius[40] states that osmazome, another nitrogenized substance, is an ingredient in the perspired fluid. It may be safely assumed, that when the skin is unable to perform its functions, the 107·47 grains of organic matter, which then lose their proper outlet, appear wholly or partly in the urine in the form of urates.

142. As already stated, the above conditions occur when the kidneys are healthy; but if organically diseased, or even merely in a state of congestion, or when the tubular structure is in a state of inflammation, as in the dropsy after scarlet fever, they allow the exudation of the albuminous elements of the blood, the vital chemistry of these organs being too far deranged to allow their filtering off the proper proportions of the constituents of urine from the system. Hence, in the disease in question, the disappearance of albumen, and the increase of uric acid in the urine, become valuable indications of convalescence. Dr. Marcet[41] was the first who suggested that interference with the functions of the skin might in some way account for calculous deposits (153).

143. Professor Liebig has recognised one great cause of the appearance of an excess of uric acid in the urine, founded on his theoretical views of the conversion of this substance into urea (83). It may be thus briefly enunciated: that as normally the insoluble uric acid presumed to be first produced by the metamorphosis of tissues is (under the influence of oxygen, supposed to be conveyed in the red blood-discs) converted into the soluble urea, whatever increases the number of blood-discs (carriers of oxygen), or quickens the circulation, must cause the more complete conversion of uric acid into urea; and less of the former and more of the latter will appear in the urine. Conversely, whatever interferes with the perfection of oxygenation in the body, must necessarily produce an excess of uric acid. From this view,[42] it follows that the quantity of uric acid ought to be positively or relatively to urea, decreased in

1. Fever.
2. Acute Phlegmasiæ.
3. Phthisis.

And conversely it should be increased in

1. Chlorosis.
2. Anæmia.
3. Pulmonary emphysema.

The only mode of testing hypotheses of this kind, emanating from a great and respected authority, is by clinical observation; and so far as recorded facts are concerned, they fail altogether to give the slightest support to the ingenious theory of Professor Liebig.*

144. The labours of Edmund Becquerel[43] in urinary pathology, furnish us with a mass of carefully recorded observations, which, made with no view of supporting or disputing any preconceived notions, are peculiarly entitled to respect. The numbers in the following table are calculated from some of the analyses alluded to, and point out the actual quantity of uric acid and urea excreted in the twenty-four hours, and the relative proportion they bear to each other in several diseases.

	Quantity in 24 hours of		Ratio of uric acid to urea.
	Uric acid.	Urea.	
	Grains.	Grains.	
Healthy urine (Becquerel's average)	8·1	255·	1 : 31·48
Chlorosis, minimum of five cases .	1·8	77·5	1 : 43·
Chlorosis, maximum of five cases .	6·	172·	1 : 29·
Pulmonary emphysema, extreme dyspnœa . . .	4·9	172·	1 : 35·1
Phthisis, tubercles softened .	9·1	66·7	1 : 7·33
Phthisis, three days before death .	9·8	29·4	1 : 3·
Morbus cordis, with icterus .	9·82	73·3	1 : 7·6
Acute hepatitis, with icterus .	11·18	61·6	1 : 5·6
Icterus	17·75	285·6	1 : 16·1
Milk fever . . .	19·	133·	1 : 7·47

* Lehmann thus writes in reference to this theory: "The pretended oxidation of the constituents of the blood, which was supposed to explain phthisis,

From this table we find that in chlorosis, a disease of anæmia, in which oxygenation of the blood, on the theory of Liebig, must be most imperfect; the uric acid, instead of being in excess, is positively and relatively below rather than above the healthy average (138). In pulmonary emphysema, again, the same thing is observed, although, from the want of integrity in the function of respiration, uric acid ought to abound; while in acute hepatitis, and in phthisis, diseases in which, on Liebig's own showing, oxidation is actively going on, the uric acid, both abstractedly and in relation to the urea, is at a minimum instead of a maximum. The curious disease, diabetes mellitus or glucosuria, seems, moreover, to offer a serious objection to the validity of the opinion, that in phthisis, excessive oxidation is a necessary condition, and therefore the uric acid must be oxidized into urea and disappear from the urine (even if it were true that uric acid deposits did not occur in this disease). Diabetes and phthisical disease of the lungs so frequently occur together, that some pathologists have even gone so far as to suppose this complication to be a necessary one. Yet here, while phthisical disorganization is pursuing its destructive course, and excessive oxidation is supposed to be rapidly destroying the tissues of the body, an abundance of a highly carbonized, indeed a readily oxidizable substance, is generated in the body, circulates in the blood, and escapes by the kidneys. An analogous argument is

as well as gout and stone, is not the simple method by which alone specific disease or individual well-characterised processes can be explained with scientific accuracy. For *there are no acute and but few chronic diseases in which the oxidation of the constituents of the blood is not diminished or impeded.*" And again, "*that there is no disease characterised by a too sudden or rapid oxidation of the blood.*" (Lehmann's 'Physiological Chemistry,' by Dr. Day, vol. i, p. 219.)

afforded us by the comparative chemistry of urine of different animals. Thus the pig is peculiarly prone to lay up enormous stores of fat in its economy, and is therefore laden with a substance whose chief function, according to the views now under consideration, is to appropriate oxygen, and yet in the urine of this most greasy animal no uric acid exists, but urea has been found in the proportion of 4·9 grains in 1000. I confess it seems difficult to conceive how excessive oxidation can be supposed to be going on contemporaneously with the copious formation of inflammable bodies, sugar and fat.

145. Is it possible in any manner to reconcile these facts, the actual result of experiment and observation, with the hypothesis of Liebig? If we admit that an amount of oxygen, requisite for the destruction of tissue alone, enters the system, uric acid ought to occur in the urine; in proportion as this amount is exceeded, the acid becomes converted into urea. Therefore, by supposing that in inflammatory affections the change of tissue (or emaciation) is so rapid in its progress under the influence of disease, that all the oxygen entering the lungs in a given time is sufficient alone for the production of uric acid, an excess of this body will occur in the urine. On the other hand, if the disease does not so rapidly emaciate the patient, the metamorphosis of tissue will proceed sufficiently slowly to allow oxygen to react on the uric acid, and but a minimum reaches the urine. By allowing this latitude to the theory, the general absence of uric acid deposits in chlorosis and anæmia, and their presence in inflammation, is accounted for. Still the great objection regarding phthisis remains, as this disease is especially mentioned by Professor Liebig in his work as one in which the excess of uric acid does not occur. But even this may be reconciled to his

views by a remark he made to me in a conversation on this very subject, that he did not mean by phthisis the disease in any stage in which disorganization of lung was going on, for here he admitted with all, that uric acid occurred in excess, but intended his remarks to apply when only the early stage of tuberculization existed, corresponding, so far as I understood him, to what is known in this country by the term tubercular cachexia.

146. Excluding all abstract theories, whenever an excess of uric acid, either alone or in combination with bases, occurs in the urine, a normal quantity of water being present (30 to 40 ounces in twenty-four hours), it may safely be inferred that one or other of the following states exists:

A. Waste of tissue more rapid than the supply of nitrogenized nourishment, as in	Fever, acute inflammation, rheumatic inflammation, phthisis.
B. Supply of nitrogen in the food greater than is required for the reparation and supply of tissue, as in	Excessive indulgence in animal food, or the quantity of food remaining the same, with too little bodily exercise.
C. Supply of nitrogenized food not being in excess, but the digestive functions unable to assimilate it.	All the grades of dyspepsia.
D. The cutaneous outlet for nitrogenized excreta being obstructed, the kidneys are called upon to compensate for the deficient function.	All, or most stages of diseases, attended with arrest of perspiration.
E. Congestion of the kidneys, produced by local causes.	Blows and strains of the loins, disease of genital apparatus.

147. It is quite possible for an excess of uric acid to exist in the urine without forming a deposit, and *vice*

versâ, the presence of a deposit does not necessarily indicate the existence of an abnormal proportion (132). It is, however, easy to discriminate between these cases, for if a deposit of the urates be present whilst the bulk of the urine in twenty-four hours is *not below the average*, it is tolerably certain that an excess of uric acid exists. But if the bulk of the urine be much below the natural quantity, a deposit may occur simply from there not being sufficient water to hold it in solution. To determine whether an excess exists, let all the urine passed in twenty-four hours be collected, well shaken, and a given quantity, as about two ounces, be mixed in a conical glass vessel with about half a drachm of hydrochloric acid. In six or eight hours crystals of uric acid will be copiously deposited on the sides of the glass. To ensure the separation of the whole, they should be allowed to repose for twenty-four hours, and may then be washed, dried, and weighed in the manner already described (19). This little operation is so easily performed, that it can scarcely be deemed troublesome; and by a simple multiplication sum, the whole amount of uric acid secreted in twenty-four hours can thus be readily ascertained without the fear of any considerable error.

148. The copious deposit of the urates occurring after eating more freely of animal food than is required for the supply of the wants of the body is a well-known phenomenon, and will occur in persons whose digestive organs are in perfect vigour, simply from a greater amount of matter being given them to assimilate than they are adequate to. In like manner, if a person's digestive powers are impaired, either partially or temporarily, as after a debauch, he will be unable to convert into healthy chyle even a small proportion of food, and hence its albuminous elements, imperfectly assimilated,

enter the circulation, to be evolved by the kidneys, and perhaps other emunctories. Particular idiosyncracies with regard to the action of the stomach on certain articles of diet also exist; thus a single cup of coffee or green tea will, in many persons, determine the formation of a deposit in the urine, as if the caffein present in these two beverages had escaped the digestive powers of the stomach, and become converted into urates.

149. The conditions above referred to apply alike to the presence of free or combined uric acid, but certain other circumstances require consideration in connection with its occurrence in a free or crystalline state only. The appearance of a deposit of urates may be caused by a mere exaggeration of a natural condition; being a simple increase in quantity of salts normal to the urine. When, however, the acid occurs in a free state, it shows that not only it may be in excess, but some change has occurred in the urine, which has separated it from the base with which it had been previously combined. A deposit of free uric acid may depend on one or other of the following conditions:

A. An excess of this acid may exist, and be separated by the kidney in too large a quantity to be all converted into urates.

B. The quantity of uric acid being normal or nearly so, certain changes occur in the urine which have induced a separation from its solvent.

So long as in the pathological states above enumerated, the quantity of uric acid is not too great to combine with the bases simultaneously excreted, whether derived, as I have supposed, from the phosphate or not (81), the urine will be transparent upon being passed,

but on cooling a more or less copious deposit of urates will take place. But if the acid exceed this quantity it is held in solution by phosphate of soda so long as the urine is warm; on cooling, being partly deposited (79) in the form of a crystalline sand or gravel (80). If, without the amount of this substance being increased, a minute quantity of a stronger acid reach the urine, the uric acid is deprived of its base, and is precipitated in crystals.

150. Of the first of these conditions the urine frequently presents a good illustration in heart-disease, especially in great hypertrophy of that organ, in rheumatism, and many phlegmasiæ. In these, it is common to find one day a deposit of urates, and perhaps on the next a sediment of crystallized uric acid will occupy the bottom of the glass vessel, and a dense stratum of urates will rest upon it.

Of the second condition, examples are furnished by cases of irritative dyspepsia with pyrosis; here a large proportion of free acid is generated in the stomach, and being absorbed, finds its way to the kidneys, setting uric acid free from any soluble urate that may be present. The acid thus generated by the stomach by disease is often considerable, far exceeding the proportion poured out during healthy digestion. In one case of scirrhous pylorus, in which the patient often vomited several pints of fluid in twenty-four hours, I found a quantity of free hydrochloric acid, equal in each pint to 22 grains of the pharmaceutical acid,[44] in addition to a sufficient quantity of some organic acid (lactic ?) to neutralize near 7 grains of pure potass. At another time the hydrochloric acid nearly disappeared, and the quantity of organic acid in each pint required for saturation nearly 17 grains of the alkali.

151. If, as has been supposed, an organic acid (lactic or butyric), be an element of the perspired fluid, it is quite possible that by being retained when perspiration is obstructed, it may find its way to the urine, and precipitate uric acid. In this way imperfect action of the skin may cause an uric deposit without increasing the amount of nitrogenized matter conveyed to the kidney (138). Seguin, in addition to the facts already stated (141), observed that perspiration was lessened during digestion, and considerably diminished when this function was imperfect. In this way, a bulky meal may be an indirect cause of an uric acid deposit, besides affording pabulum for the formation of urates (147).

152. Uric acid and urates may occur in great abundance in the urine, so as to be serious sources of irritation, and then especially become primary objects of attention as definite diseases. Still we must never forget that a mere deposit of urates may be the result of causes hardly amounting to disease, and may be rather regarded as an evidence of the integrity of the depurating functions of the kidneys than of their lesion. We have frequently occasion to disabuse our patients' minds of very erroneous opinions they have entertained on this point, which have added very seriously to their anxieties by apprehensions of impending disease. Uric acid or urates may be deposited in an insoluble form in the kidney or bladder, and aggregating, form a mass, on which, by a kind of imperfect crystallization, great quantities of the acid or its salts may be deposited, giving rise to the formation of a calculus. Uric acid is of more serious importance than most other elements of calculous formations, not only from its constituting a large proportion of all urinary calculi, but even when they are chiefly composed of other ingredients, the nuclei on which they are deposited are, in the great

majority of cases, composed of uric acid. Of 374 calculi contained in the museum of Guy's Hospital, at the time I examined them, the nuclei are in 269 composed of uric acid or urate of ammonia alone.[45]

On account of its solubility (130), urate of ammonia is not a frequent component of entire calculi, although it often enters with other ingredients into their composition. Indeed, calculi wholly composed of this compound are almost peculiar to childhood; in Guy's museum there are but eight concretions entirely consisting of this substance, although it constitutes the nucleus in eighteen. It is hence very probable that if ever by medical treatment we can succeed in overcoming a calculous diathesis, or dissolving a stone in the act of growth, it will be by means directed to the solution of the uric acid or its combinations.

153. Regarding the medical treatment of the different forms of uric acid gravel (limiting this term to deposits occurring so persistently or abundantly as to have become primary sources of irritation or annoyance) much might be said. Discarding altogether the existence of any specific agent for a disease which is rather symptomatic of another affection than really idiopathic, the therapeutical agents may be briefly referred to the following heads:

Attention to the function of the skin.—The remarks already made on the effect of an arrest of perspiration in furnishing a pabulum for the formation of a deposit (138), or by retaining in the circulation a substance capable of rendering uric acid insoluble (151), show the necessity of attending to this indication. I have repeatedly seen diaphoretics, warm clothing, the use of a flannel, and in winter, even a chamois leather waistcoat, with friction by means of a flesh-glove or hair-glove, repeatedly remove a deposit of uric acid gravel; and in more than one instance,

where even an hereditary taint existed from gouty or calculous progenitors. The observations of Dr. Wilson Philip[46] have shown that the proportion of uric acid in the urine is notably diminished by the use of active diaphoretics. It is also probable that the extreme rarity of calculous affections in the navy might be partly explained by the kind of vapour-bath in which sailors sleep, "the lower decks being the parts allotted to repose, the ports are, for the safety of the ship, necessarily closed at night, and the temperature of the surrounding air is thereby so exalted, that the place becomes a kind of steam-bath from animal exhalations; the men being literally immersed in their own perspiration." These are the remarks of Mr. Copland Hutchinson,[47] who, in allusion to the rarity of calculus among sailors, adds that from 1800 to 1815, upwards of 126,000 men were employed in the navy. Of these, nine tenths had been employed at sea from a very early period of life. Only eight were affected with stone. It appears probable that three of these were affected with calculus before entering the service. So that taking all the cases in the navy in the period above mentioned, it cannot be said that more than 1 in 34,000 were the subject of calculus.

154. My own experience induces me to regard the warm, or still better, the vapour-bath, as the most valuable diaphoretic. The latter is readily employed in private practice by means of the very convenient and portable apparatus of M. Duval, which has for a long time superseded other forms of vapour-bath at Guy's Hospital.* Actual diaphoresis is by no means necessary in the treat-

* I cannot avoid here strongly recommending a very economical and excellent vapour-bath quite equal in its effects to the more expensive apparatus of M. Duval, invented by Mr. Moss, of Bartholomew Square, Old Street, London.

ment of all cases of uric gravel; friction to the skin, and, when persons are sufficiently robust, immersion in the cold-bath, or cold sponging on rising from bed, followed by rubbing the surface of the body with a dry and rough towel, until reaction is produced, is often of great service.

155. *Restoring the tone of the organs of digestion.*—By effecting this, a double object is attained; the perfection of the primary assimilation of the food by which the entrance into the blood of a crude nitrogenized matter, capable of being converted into uric acid, is checked (148); and the prevention of the generation of any acid, the product of unhealthy digestion (150), which might be absorbed into the circulation, reach the kidneys, and act as a precipitant of uric acid. This part of the treatment of calculous affections must be modified by the peculiarities of the case, and, indeed, is identical with that of the different forms of dyspepsia. Careful attention to the bowels, avoiding excessive purging, the use of minute doses of mercury, as of a grain of pil. hydrargyri or hydrarg. c. creta, with thrice that quantity of ext. conii, administered two or three times a day, with moderate doses of the carbonates of potassa or soda, in the mist. gentianæ comp., if constipation exist; or if not, in inf. calumbæ, or what is preferable, from its action on the skin, inf. serpentariæ; will often effect immense relief. Where gastrodynia, with or without pyrosis, exists, the use of half a grain of argenti nitras, or one of argenti oxidum, immediately before a meal, will often check alike the gastric and renal symptoms. But the most important element in the treatment is a rigid attention to the quality and quantity of the ingesta, taking the utmost care to select those articles of diet which the patient can thoroughly digest, it *being of far greater importance, in the majority of cases, to regard this*, than to choose articles of food according to their

chemical composition. A too bulky meal of animal or vegetable food is injurious to persons labouring under calculous dyspepsia, for whilst the former supplies too much nitrogen, both will become sources of mischief by overloading the digestive functions, and preventing the chylopoietic viscera doing their duty (148). In protracted cases, however, much good is derived by actually cutting off part of the supply of nitrogen. In this way, I have seen a copious deposit of uric acid gravel disappear, after other measures had failed to give relief.

156. The following case is a good illustration of the latter mode of treatment:

Exposure to cold. Uric acid deposits, resisting ordinary treatment, relieved by diaphoretics, and cured by excluding nitrogenized food.—John Lynch, æt. 37, admitted into Guy's Hospital, on October 2d, 1839. By trade a porter in a warehouse in Spitalfields, and constantly exposed to alternations of temperature. When young he had lived freely, and partaken to excess of spirits and malt liquors, and had eaten meat daily. His health, up to the present illness, had been excellent. No hereditary taint of calculus or gout. On admission, he stated that nineteen months previously he had got very wet, and allowed his clothes to dry on him; this was followed by fever and profuse perspirations. The next day he became the subject of rheumatic pains, from which he had never since been free. He complained of constant pain in the region of the kidneys, increased by pressure and flexing the trunk, and some pain at the extremity of the penis. He passed water thrice in the day and once at night, each time discharging uric acid gravel most copiously. The latter symptom had been present a twelvemonth. The urine was not coagulable, contained some mucous flocculi, and the deposit of gravel did not disappear by boiling. The tongue was clean and moist, he complained of habitual heartburn, had occasional bilious vomitings, the bowels were generally relaxed, and he was griped or purged on slight causes, especially by exposure to cold. Pulse 78, natural. From October 2d to November 27th his treatment consisted of purgatives, soda and uva-ursi, occasional mild mercurials, under which the deposit decidedly increased. He then took dec. alchemillæ with potass without relief.

November 27th to December 18th.—A trial of diaphoretic treatment was made. The warm bath twice a week, with Pulv. Ipecacuanhæ comp., gr. viij,

ex. Julepi Ammon. Acet., ℥j, twice a day. Under this treatment he improved, the skin acted profusely, and the deposit gradually disappeared.

January 10th, 1840.—The urine up to the present time remained healthy; he went out of the hospital, took cold, checked the perspiration, and the uric acid deposit appeared as abundantly as before. He was again relieved by the diaphoretic treatment, but soon afterwards relapsed. It was therefore determined to confine his diet to arrowroot, sago, potatoes, bread and butter, excluding the four ounces of cooked meat he had previously daily taken. The effect was very remarkable, the deposit almost immediately disappeared, and he remained free from it up to February 25th, when he was discharged. On one occasion the urine of this man deposited in twenty-four hours upwards of 30 grains of uric acid.

157. Moderate muscular exertion and a due amount of exercise are quite essential in the treatment of this disease; for not only do they call into play some very important functions, but often improve the general health. Besides this, when the stomach is able to digest nitrogenized food imperfectly, exercise will often aid its assimilation by making a call upon the chylopoietic organs to supply the consequent waste of tissue.

158. Among the remedies which appear most successful when the food is not converted into healthy chyle, and an unhealthy state of the blood from the presence of imperfectly assimilated matters results, the preparations of iron deserve notice. I have repeatedly seen copious deposits of uric acid in persons of low power completely disappear, *pari passu* with the cure of the pseudo-chlorotic symptoms present, by the use of this important drug. The best mode of administering it, is in combination with a vegetable acid, as the stomach bears it well in this form, and it is probably more likely to enter the circulation. From six to nine grains of the ammonio-citrate or ammonio-tartrate of iron taken thrice a day *immediately after a meal* in a glass of water, has been most successful. The solution of the sesqui-acetate of

iron is also a very valuable preparation, but is often inconvenient to prescribe, in consequence of its not being of constant strength.

159. There is one other remedy which appears to exercise a marked and decided control over the formation of uric acid, although its effects are by no means so constant as might be wished. I refer to colchicum. Wherever the general health appears to be tolerably good, and any marked irregularities of the digestive functions been corrected, I would recommend the careful and guarded administration of this drug in small doses, especially when there is an hereditary arthritic taint in plethoric patients. In several cases I have succeeded completely in checking a long-continued secretion of uric acid by the use of the ext. colch. acet., in doses of a grain twice a day, with or without the addition of a grain of pil. hydrag., and keeping up at the same time a moderate action in the bowels, by some tonic aperient, as the inf. rhei or mist. gentianæ co.

160. *Remedies which act as solvents of uric acid.*—These chiefly consist of the alkalies and their carbonates, biborate and phosphate of soda, benzoic and cinnamic acids. As the alkaline urates are far more soluble than the free acid, soda and potass with their carbonates have been long popular remedies in the treatment of uric gravel. They, moreover, may exert a beneficial effect in neutralizing any free acid in the primæ viæ, and thus prevent a precipitant of uric acid reaching the kidneys.

Liquor potassæ; this drug may be employed in doses of half a drachm thrice a day; it is best taken about an hour after a meal, and may be conveniently administered in any bland vehicle, or in a little bitter ale, which conceals much of its disagreeable flavour. It is quite use-

less to administer this remedy in the very minute doses in which it is frequently given. The liquor potassæ of the Pharmacopœia does not contain more than about one grain of potass in ten minims, and the generally recognised greater value of Brandish's alkaline solution does not depend on any peculiar properties of this fluid, but solely on its containing more potass, and in being administered in larger doses. I have scarcely ever seen the urine rendered alkaline by the usual medicinal doses of liquor potassæ; and Dr. B. Jones has shown that an ounce of this fluid administered in three days does not prevent the appearance of the acidity of the urine before food, although it much diminishes its intensity.

The carbonates of potass and soda; these are far more agreeable, and perhaps more efficient remedies,—of these the bicarbonate of potass deserves the preference. It should be given thrice a day in doses of ℈j or ʒss. I think it appears to act best when taken in a glass of warm water. To make it more agreeable, I generally order ʒss of bicarbonate of potass and gr. v of citric acid to be stirred into a tumbler of warm water. This mixture evolves enough carbonic acid to be "sparkling," and is generally taken with readiness.

To render this treatment efficacious, it is quite essential that the patient should partake very freely of diluents. Two or three pints of water drunk during the day will double the bulk of the urine, and remarkably aid the solution of uric acid. Indeed, it has been well remarked that pure water is one of the best lithontriptics.

161. The influence of the waters of Vichy is well known, and they have acquired a really well-merited reputation in cases of uric acid gravel. These waters owe their efficacy to the presence of carbonate of soda. The artificial Vichy water prepared at the German Spa, at

Brighton,* and which may be procured in pint bottles, possesses all the value of the mineral water. Indeed, I think, it is preferable from its purity, and from its being more highly charged with carbonic acid. I have seen the greatest advantage gained by the use of a small tumblerful of this water on rising in the morning, and a second at dinner. To the latter dose, a glass of Madeira or pale sherry, may be sometimes added where

* The following analysis of the artificial Vichy water prepared at the German Spa at Brighton is by Dr. Letheby, and is quoted by Dr. Hassall in his review of the previous edition of this work in the 'British and Foreign Medico-Chirurgical Review:' "The water is effervescent from free carbonic acid. It is alkaline to test paper, and has a specific gravity of 1005. Two thousand grains were evaporated, and yielded 9·80 grains of a very white saline residue, which consisted of—

Sulphuric acid	0·34
Chlorine	0·70
Carbonic acid	3·93
Soda	4·19
Potassa	traces
Lime	0·34
Magnesia	0·18
Silica and alumina	0·12
	9·80

These constituents may be arranged in two ways, thus:

	1	2
Bicarbonate of soda	10·14	9·50
" magnesia	0·58	0·58
" lime	0·26	0·87
Sulphate of lime	0·58	...
" soda	...	0·60
Chloride of sodium	1·16	1·16
Silicate of alumina	0·12	0·12
	12·84	12·83

The first is the most probable arrangement of the elements; but the second form is introduced in order to show how closely this water resembles that

wine is desirable. The mixture forms a most agreeable beverage.

162. *Salts of the vegetable acids.*—A very convenient mode of impregnating the urine with an alkali is to administer the potass or soda in combination with a vegetable acid, especially with the acetic, citric, or tartaric. The mode in which these act is easily explained; when acetate, citrate, or tartrate of potass are ignited, the acid absorbs oxygen, and is converted into carbonic acid and water, part of the former uniting with the alkali. In a similar manner are these salts decomposed during the process of healthy digestion; a carbonate (389) finds its way into the circulation, and, reaching the kidneys, renders

from the wells of Vichy, examined by Henry in 1847. The following analyses are from his paper on the subject:

	1 *Source Grande Grille.*	2 *Source Nouvelle.*	3 *Source Pré Salé.*	4 *Nouvelle Source Célestines.*
Bicarbonate of soda	9·80	9·68	9·40	8·27
" lime	0·21	0·18	0·89	0·55
" magnesia	0·13	0·11	0·81	0·42
Sulphates of soda and potash	0·97	0·82	0·52	0·38
Silicate of alumina	0·46	0·46	0·14	(?)
" soda	0·80	0·68	0·55	0·28
Alkaline chlorides	1·08	1·00	0·60	0·76
	13·45	12·93	12·91	10·66

"The water also resembles the alkaline springs of Cusset and Hauterine in France. In fact, there is but little difference in the composition of the alkaline waters of Vichy, Cusset, and Hauterine; and the artificial water from the Spa at Brighton is a very good imitation of all of them. It will be observed from these analyses that the active ingredient in all these waters is bicarbonate of soda. The dose of Vichy water is a small tumblerful two or three times a day, which amounts to about a pint, and contains 35·5 grains of bicarbonate of soda."

the urine alkaline. If, however, the digestive powers are impaired, the vegetable acid is only partly decomposed, and in some few persons it escapes the influence of digestion altogether. 114 grains of tartrate of potass, 106 of citrate, 99 of the acetate, absorb respectively 40, 48, and 64 grains of oxygen, to be converted into carbonate of potass and water. These salts may be administered by directing the use of the common saline powders made with carbonates of potass or soda and the citric or tartaric acid in effervescence.

Tartrate of potass readily renders the urine alkaline; half an hour being sufficient to render its effects on the urine apparent; in doses of thirty grains dissolved in at least two ounces of water, it may be conveniently given three times a day. During its administration, the uric acid deposits disappear, and the urine rises in specific gravity. There is one great objection to this salt in its tendency to irritate the bowels. On this account, as well for the sake of its more grateful flavour, I am accustomed to prefer the acetate of potass. Thirty grains of this salt, with a drachm of syrup of orange-peel, and a drop or two of oil of lemon, constitute a most agreeable draught to which the most fastidious patient seldom objects. In this way the urine may be kept in a moderately alkaline state for any length of time, without interfering, as the free and carbonated alkalies are apt to do, with the function of digestion. We thus preserve the patient from the probability of the formation of a calculus, and gain time for the employment of remedies calculated to remove the exciting cause of the uric acid diathesis.

163. It is a remarkable fact that in the Rhenish provinces, where the common beverage of the inhabitants consists of poor wines containing a considerable quantity of bitartrate of potass, calculous affections are unknown.

A circumstance admitting of explanation by the decomposition of the bitartrate into carbonate of potass, which thus prevents the urine becoming sufficiently acid to allow the deposit of uric acid. When not contra-indicated, the use of roasted apples, strawberries, currants, and some other fruits containing alkaline citrates and malates, are capable of making the urine alkaline, and may be occasionally employed with advantage.

Some persons cannot bear the use of free or carbonated alkalies without suffering severely in their general health, nor is their protracted use altogether without some ill effect. A flabby state of the muscles, and an anæmiated condition of the system are frequently produced by the persistent use of alkaline remedies. Their injudicious employment may, indeed, possibly induce the formation of oxalic acid.

It must not be forgotten that the urine cannot be rendered alkaline for any length of time without risk of precipitating the phosphates of lime and magnesia, thus giving the patient a change of evils instead of removing them. In reading the accounts recorded of the treatment of real or imaginary calculous affections a century ago, by the celebrated alkaline remedy of Miss Stevens, it is impossible to avoid noticing how very much of the sabulous and fetid state of the urine of her patients was obviously engendered, not by the disease, but by the remedy.

164. *Biborate of soda.*—Uric acid is soluble in a solution of borax, the biborate of soda,—more so, indeed, than in alkaline carbonates; and this salt may be taken for some time, at least by male patients, without producing any very injurious constitutional effects, and readily finds its way into the urine. On this account its administration has been suggested in cases of uric acid gravel,

but it has not been much employed in this count y. In women, this drug cannot be employed with impunity, as it certainly exerts a stimulant action on the uterus, and I have seen it in two instances produce abortion.

The borate of potass has been strongly recommended as a substitute for ordinary borax, on account of its greater efficacy as a solvent for uric acid. M. Bouchardat recommends the following remedy as very efficacious in uric gravel; it should be mixed with as large a quantity of water as can be conveniently drunk, and taken several times in the day whilst effervescing. If it purges, it of course must be taken less frequently, or in smaller quantities.

℞ Potassæ bitartratis, ʒj, gr. xv;
,, boratis,
,, bicarbon. āā, gr. xv. M.
Fiat pulvis.

165. *Phosphates of soda and ammonia.*—The remarkable solvent action of phosphate of soda on uric acid, to which Liebig directed attention (79), inspires a hope that its administration may be of use in cases of calculous disease, by impregnating the urine with an active solvent. All that is required to ensure this drug reaching the urine is to administer it in solution sufficiently diluted; ℈j to ʒss might be administered in any vehicle, as in broth or gruel, for when diluted the phosphate tastes like common salt, and few persons object to its flavour. I have administered this drug in several chronic cases of uric acid gravel, and in some with the effect of rapidly causing a disappearance of the deposit. The triple salt, ammonio-phosphate of soda, would, perhaps, be a more active remedy than the simple phosphate, but its disagreeable flavour constitutes an objection to its employment.

166. Dr. Buckler, of Baltimore, has proposed the use of phosphate of ammonia in the treatment of the uric acid diathesis, whether this body be deposited in the urine as a calculous formation, or in the joints combined with soda, as in rheumatic gout. The practice has also been sanctioned by subsequent writers. This salt may be given in doses of ten grains thrice a day dissolved in any bland vehicle. I have given it a fair trial in hospital practice, and have no hesitation in saying that it has always succeeded in keeping uric acid in solution in the urine, and in this respect it has appeared to be at least equal, if not superior, to borax and phosphate of soda, but I certainly have never seen it diminish the tophaceous deposits in chronic gout. In more recent effusion into the joints of subacute forms of rheumatic gout it has certainly been of service.

167. *Benzoic acid.*—Much attention has been drawn to the effects of benzoic acid in preventing the formation of uric acid, by the observations of Mr. Alexander Ure.[49] When this acid or its salts are administered, they are acted upon by the stomach in a very different manner from the other vegetable acids. Instead of becoming oxidized, and converted into carbonic acid, benzoic acid combines with those nitrogenized elements which would otherwise have formed urea or uric acid, and is converted into hippuric acid (96). It has been stated that the quantity of uric acid falls, when the benzoic acid is administered, below the average quantity, or even disappears from the urine. This has been, however, shown to be an error by Dr. Garrod,[50] who has observed that the urea alone diminishes in quantity. Be this as it may, it is certain that the acid does appropriate to itself some body rich in nitrogen to form

hippuric acid; and experience has shown that, in cases where an excess of uric acid is secreted, the administration of this drug appears to limit it to about the normal quantity. The body with which benzoic acid combines, has the same composition as glycocoll or sugar of gelatine, and is, in all probability, identical with it.

	C N H O
1 atom benzoic acid	14+5+0+3
+1 „ glycocoll	4+4+1+3
= Hippuric acid	18+9+1+6

168. If ten or fifteen grains of benzoic acid be swallowed on retiring to rest, and the urine passed on rising from bed the following morning be examined, it will be found to contain abundance of hippurate of ammonia. A couple of drachms of it evaporated in a watch-glass to a few drops, and mixed with hydrochloric acid, generally becomes nearly solid in a short time from the deposition of delicate interlacing needles of hippuric acid.

This transformation of benzoic into hippuric acid seems to be very rapid, for the latter can be detected in the urine within half an hour after a dose of the former has been swallowed. The weight exceeding that of the benzoic acid employed, by about one third.

Benzoic acid may be administered in doses of eight or ten grains in syrup, or dissolved in a weak solution of carbonate or phosphate of soda thrice a day. Cinnamon water forms a good vehicle, as cinnamic acid exerts a similar action to the benzoic, becoming converted into hippuric acid. I have found the following

formula of great service in several cases of chronic uric acid gravel:

> ℞ Sodæ Carbonatis, ʒiss;
> Acidi Benzoici, ℈ij;
> Sodæ Phosphatis, ʒiij;
> Aquæ Ferventis, f℥iv, solve et adde
> Aquæ Cinnamomi, f℥viiss;
> Tincturæ Hyoscyami, fʒiv.
>
> Fiat mistura cujus sumat æger, coch. ij, amp. ter in die.

Perhaps a more efficient remedy is found in the benzoate of ammonia, a salt indeed to which Dr. Holland has directed the attention of the profession. This may be extemporaneously prepared by dissolving five or six grains of benzoic acid and as much sesquicarbonate of ammonia in an ounce of boiling water. A very nearly neutral solution is thus obtained, which may be given thrice a day with the addition of a little syrup, and twenty or thirty minims of tincture of henbane. Benzoic acid is one of the very few acids which decidedly increase the acidity of the urine, and (in addition to its chemical action) it acts beneficially by exciting diaphoresis, and thus fulfils an important general indication in the treatment of calculous affections (153).

169. It is important to bear in mind that by the employment of remedies capable of dissolving a deposit in the urine, *we are merely palliating, not curing the disease.* And we must never lose sight of the great importance of endeavouring to remove that pathological state of the whole system, or of any particular organ, which may be the exciting cause of the calculous formation. Nothing but a careful investigation of symptoms can put us in possession of the knowledge necessary for this purpose. Still, solvent remedies are not to be despised;

for when the disease is chronic, and does not readily yield to treatment, it is of the utmost importance to prevent the formation of a calculus, or lessen the irritation produced by the presence of gravel, whilst endeavouring to remove the primary affection which led to the formation of the deposit; and hence these indications should be carefully attended to.

We are rarely called upon to treat deposits of urates as special diseases, as they are generally not persistent and are readily traced to their exciting cause. Sometimes, however, patients become fearfully depressed and nervous from the constantly muddy character of the urine, and in spite of an assurance that there is no fear of a calculus, we are compelled to treat the affection. In such cases, any saline diuretic, as the nitrate of potass in doses of ten grains, or, still better, the acetate in doses of a scruple, pretty largely diluted, and taken three times a day, will soon cause the deposit to vanish.

170. I cannot avoid alluding here to an empirical remedy sold under the absurd name of "constitution-water;" this is prepared by a person residing at Henley-in-Arden, who has, I believe, an enormous sale for it. This remedy owes its virtues to the presence of impure carbonate of potass, probably obtained directly from the ashes of some vegetable matter. On examining a specimen of this preparation I have found it to have a specific gravity of 1·023. It effervesced with acids, and exerted an alkaline action on turmeric paper. Saturated with nitric acid, it copiously precipitated nitrate of barytes, nitrate of silver, and oxalate of ammonia. It hence contained sulphates, chlorides, and a salt of lime. A fluid ounce supersaturated with sulphuric acid, and evaporated, left 10·8 gr. of sulphate of potass after ignition, equivalent to very nearly 5·9 grains of potass exist-

ing in the fluid combined with carbonic acid. There can be no question of the advantage that has resulted in some cases from the use of this remedy, nor, on the other hand, can there be any doubt of the injury it has inflicted when improperly administered. The secret of its success in uric acid gravel (the only class of cases in which it should be employed) depends upon the large quantity of the alkaline salt administered in twenty-four hours. Our doses are generally too small when alkalies are administered in such cases, and I certainly owe the knowledge of this fact to some successful results of the so-called constitution water. I now constantly prescribe, with very great advantage, especially in the cases of *pisiform* uric acid gravel (in which patients will pass scores of calculi, the size and appearance of mustard-seeds, at a time), in imitation of this preparation, from two to four drachms of bicarbonate of potass, dissolved in 30 or 40 ounces of water, in the course of twenty-four hours.

CHAPTER V.

CHEMICAL PATHOLOGY OF URIC OXIDE.

Xanthi-uria.

History, 171—Diagnosis of uric oxide, 174, 175—Characters of urine depositing, 175—Microscopic character of, 176—Pathological indications, 177—Excreted by spiders, 179.

Uric Oxide.

Syn. Xanthic oxide—Xanthine—Urous acid.

171. This substance has not been discovered among the constituents of healthy urine, although it is probable that it bears some relation to the yellow colouring matter; and hence it may possibly exist in minute quantities, and have escaped the investigations of chemists. But little is known either of the chemical or pathological history of this very rare ingredient of calculous concretions. It was first met with by Dr. Marcet,[31] constituting the whole of a small calculus weighing but eight grains; the history of the case being unknown. Some years afterwards, some minute pisiform concretions passed by a gentleman with diseased bladder were found by M. Laugier[25] to consist of uric oxide. More recently this substance was discovered in a stone removed

by Professor Langenbeck, of Hanover,[53] from a boy eight years of age. It weighed 338 grains, and after examination by Professor Stromeyer, was submitted to minute chemical investigation by Professors Wohler and Liebig. A fragment of this calculus has been, by the kindness of my friend, Dr. Willis, placed in the museum of Guy's Hospital. A fourth specimen, weighing but seven grains, was lately removed from the urethra of a boy by Professor Dulk of Konigsberg.[54] Uric oxide has been met with in deposits by Berzelius,[55] M. Morin, of Geneva,[56] and one or two other observers.

172. A substance closely allied to uric oxide, and termed *guanine*, has been observed by Dr. Unger in the Peruvian guano, the dried excrementitious matter of seabirds. To obtain it, he directs guano to be digested in milk of lime until the solution assumes a yellowish-green tint, the mixture is then filtered, and hydrochloric acid added; a mixed precipitate of uric acid and guanine falls. On boiling this with hydrochloric acid guanine dissolves, and on cooling, a compound of it with the acid crystallizes. This, on being digested with ammonia, leaves guanine pure in the form of a white powder.[122] Guanine is a white pulverulent body, quite insoluble in water, without any alkaline action on test-paper, but yet is a tolerable active base, forming salts with several acids. The sulphate crystallizes in long brilliant needles. It contains 46·62 per cent. of nitrogen, and its atomic composition is C_{10}, N_5, H_5, O_2.

173. Very recently, another body allied to uric oxide has been discovered by Professor Scherer in the spleen and heart both in man and the ox (39). This substance he has termed *hypo-xanthine*, and it is scarcely soluble in cold water, requiring 1090 parts for solution; but dissolves in 180 parts of boiling water. It contains 40·8 per cent.

of nitrogen, and its atomic composition is C_5, N_2, H_2, O_1. It is often found in such large quantities in the spleen, that it is deposited from a boiling decoction by mere cooling.

174. *Diagnosis of uric oxide.*—Concretions composed of this substance closely resemble, and are generally mistaken for, uric acid. They present externally a similar appearance, but their sections are of a well-marked salmon, or rather cinnamon tint, which, to a practised eye, will distinguish such concretions from uric acid. According to Berzelius, when uric oxide forms an urinary deposit, it appears as a gray powder. In the only case in which I ever met with a deposit composed of a substance approaching uric oxide in chemical characters, it presented a honey-yellow colour. A wax-like lustre is readily assumed by submitting fragments of uric oxide to friction. If a deposit be suspected to consist of, or to contain this substance, it should be digested in a weak solution of carbonate of potass, which removes uric acid, and leaves the oxide undissolved. So closely do these two bodies resemble each other, that their diagnostic distinctions will be best observed by contrasting their action towards reagents.

Uric oxide.	*Uric acid.*
1. Dissolves slowly in nitric acid almost without the evolution of bubbles of gas.	1. Dissolves readily in nitric acid with copious effervescence.
2. The nitric solution leaves by evaporation a yellow residue.	2. The nitric solution leaves by evaporation a pink residue.
3. Soluble in strong sulphuric acid, not precipitated on the addition of water.	3. Is precipitated by water from its solution in concentrated sulphuric acid.
4. Its solution in liquor potassæ is not disturbed by hydrochlorate of ammonia.	4. Hydrochlorate of ammonia precipitates it combined with ammonia from its solution in liquor potassæ.

5. Precipitated uncombined, when a current of carbonic acid traverses its solution in potass.	5. A current of carbonic acid gas throws down from the alkaline solution an acid urate of potass.
6. Insoluble in solution of carbonate of potass.	6. Readily soluble in dilute solution of carbonate of potass.
7. Ignited in a tube, does not yield urea.	7. When ignited, yields urea as one of its products.

This substance might also be confounded with cystine, but may be distinguished from it by its insolubility in hydrochloric and oxalic acids, and by its want of crystalline form as viewed by the microscope.

Uric oxide has constituted the whole mass of the calculus in all, except in that examined by Professor Dulk, in which the nucleus consisted of uric acid. According to him, uric oxide furnishes, with nitric acid, some of the same products which uric acid yields, especially alloxantin.

175. *Characters of urine depositing uric oxide.*—Unknown, no observations of the urine of the persons from whom calculi of this substance were removed having been recorded.

176. *Microscopic characters of uric oxide.*—This substance does not appear to assume a crystalline form. A careful microscopic examination of the fragment of the calculus removed by Langenbeck, and now in the museum of Guy's Hospital, failed in detecting any appearance of crystalline arrangement. I dissolved a portion of this concretion in liquor potassæ, and precipitated the oxide very slowly by the cautious addition of acetic acid. Uric oxide fell in a perfectly amorphous state, presenting none of the well-defined crystalline form which uric acid assumes when similarly treated.

The only instance (174) in which I had reason to believe a deposit was made up of this substance was in the urine of a child, which let fall by cooling a honey-

yellow sediment. This, on microscopic examination, by reflected light, was found to be composed of rather large yellow masses, having much the appearance of yellow wax, and presented no trace of crystalline structure. This substance was replaced in the next specimen I examined, by uric acid.

177. *Pathological and therapeutical indications.*—Unknown, although from the remarkable similarity of their composition it is highly probable that the majority of the remarks already made on the pathology of uric acid apply to that of the oxide. Uric oxide consists of C_5, N_2, H_2, O_2; if, therefore, we suppose two atoms to be oxidized by combining with two of oxygen, one atom of uric acid will be found.

	C N H O
2 atoms uric oxide	10+4+4+4
+2 " oxygen	2
=1 " uric acid	10+4+4+6

178. The relation of the hypo-xanthine recently discovered in the spleen and heart (in which organs it seems to constitute the transition stage, assumed wholly or partly by the old and exhausted tissue before their transformation into the elements of urine) to uric oxide, and consequently uric acid, is peculiarly interesting.

	C H N O
1 atom uric oxide	5+2+2+2
−1 " oxygen	1
=1 " hypo-xanthine . . .	5+2+2+1

179. Dr. John Davy has announced his belief that the urinary excretion of scorpions and spiders consists chiefly of uric oxide. He obtained a body presenting all

the properties of this substance from the excrements of all the different spiders he examined; whilst in those of true insects he found uric acid exclusively.

It is remarkable that in most of the recorded cases, the uric oxide has occurred only in children. One observer stated that he had met with it as a deposit in diabetic urine.[67]

Very recently two German chemists, MM. Strahl and Lieberkühn,[152] have announced the existence of traces of uric oxide in human urine. But if the body they have described is to be regarded as a normal ingredient of urine, it, as Lehmann has suggested, is more likely to be identical with guanine, on account of its solubility in hydrochloric acid.

CHAPTER VI.

CHEMICAL PATHOLOGY OF PURPURINE.

(*Porphy-uria.*)

180. The chemical characters of this remarkable colouring matter have been already pointed out, but it merits some notice as a pathological product, from the serious lesions its presence frequently indicates. On account of its solubility in water, purpurine never occurs as a deposit, unless the urates are present, which have the property of removing a considerable proportion of purpurine from urine, and assuming thereby a more or less deep carmine tint.

181. *Diagnosis.*—When a deposit of urates is coloured by this substance, it presents a tint varying from the palest flesh colour to the deepest carmine. To appreciate the beauty of these tints, the deposit should be collected on a filter, and allowed to dry. The presence of purpurine favours the deposit of urates and interferes with their ready solubility on the application of heat;

and free dilution with water is often required to aid their solution. I have never seen purpurine colouring any other deposits except those of urate of soda, and hippuric acid when precipitated from concentrated urine by hydrochloric acid. Uric acid scarcely appears to have any affinity for it. It is by no means uncommon for a very highly coloured deposit of pink urates to be by a careless observer mistaken for blood, and I have seen this error committed when it occurred in albuminous urine. The appearance of the deposit when collected on a filter, and its giving up the purpurine to alcohol, will at once remove any doubt on the subject, and the absence of blood-discs on microscopic examination will aid in demonstrating the real nature of the deposit.

182. The chemical composition of purpurine, occurring as a product of disease, is unknown. This body bears no analogy whatever to murexid or purpurate of ammonia, substances with which it was long confounded, owing to the countenance afforded to this opinion by the high authority of Dr. Prout. This want of identity is so clearly made out that I have deemed it unnecessary to adduce the evidence brought forward in the first edition of this work on the subject. According to Scherer, the purpurine generated by the action of hydrochloric acid on urine consists of—

Carbon	62·51
Hydrogen	5·79
Nitrogen, Oxygen	31·70

There are several calculi in Guy's museum, with layers of urate of ammonia deeply stained with purpurine. Similar calculi have been described by Mr. Taylor,[69] as occurring in the museum of St. Bartholomew's Hospital,

and Brugnatelli[49] has recorded many instances of the same kind.

183. *Microscopic characters.*—Always those of the deposit with which the purpurine is combined. All the sediments I have met with were amorphous. I possess one specimen, however, of a rich pink colour, given me by Dr. Percy, in which the deep crimson urate is composed of minute ovoid particles acuminated at both extremities, and possessing a crystalline lustre.

184. *Characters of the urine containing purpurine.*—It invariably happens that when an excess of the urates is present, they, on the urine cooling, fall to the bottom of the vessel, carrying down a great part of the purpurine. If this excess be not present, the urine simply presents a pink or purple colour, and on dissolving white and pure urate of ammonia in it by heat, it is precipitated on cooling deeply coloured by the purpurine. The presence of the yellow extractive which yields purpurine, can be readily discovered by the action of hydrochloric acid as already described (102).

On evaporating urine containing purpurine to the consistence of an extract, and digesting it in alcohol, a fine purple tincture is obtained, the intensity of the tint being rather heightened by acids and diminished by alkalies.

The specific gravity of this highly coloured urine is subject to great variation; when the colour is as deep as brandy, its density varies from about 1·022 to 1·030. The addition of nitric acid generally produces an immediate muddy deposit of uric acid, made up of microscopic rhomboids, which has been more than once mistaken for albumen.

185. *Pathological indications.*—The presence of an excess of purpurine appears to be intimately and invariably

dependent upon some imperfection in the excretion of carbon by those organs whose special function it is to eliminate this element from the blood, as the liver and lungs, but especially the former. It hence is almost always connected with some functional or organic mischief of the liver, spleen, or some other organ connected with the portal circulation. The appearance of a flesh-coloured deposit in the urine is the commonest accompaniment of even slight derangement of the hepatic function, as every case of dyspepsia occurring in gin-drinkers points out. The intensity of colour of the deposit appears to be nearly in relation with the magnitude of the existing disease. In the malignantly diseased, in the contracted, hobnail, or cirrhosed liver, the pink deposits are almost constantly present in the urine. They are also of frequent occurrence in the hypertrophy of the spleen following ague. The most beautifully coloured deposits I have seen have occurred in ascites connected with organic disease of the liver; and I think I have received some assistance in the diagnosis between dropsy depending upon hepatic and peritoneal disease, in the presence of the pink deposits in the former, and their general absence in the latter. I have occasionally seen the deposits in question occur in phthisis, when large quantities of pus were poured out from vomicæ, as well as in deep-seated suppuration, as in psoas abscess. But even in these cases, the excretion of carbon and the integrity of the portal circulation are always more or less influenced. My experience, indeed, leads me to express a firm belief that an excess of purpurine is almost pathognomonic of disease in the organs in which portal blood circulates, and consequently must be essentially connected with the non-elimination of the carbonized elements existing in that fluid. Indeed, from very careful obser-

vations especially directed to the pathological indications of these pink deposits, I doubt their ever occurring even in phthisis or other affections of a strumous character, unless the liver present obvious evidence of derangement either in its structure or functions. I am anxious to direct attention to this fact, for instances have occurred to me in which the presence or absence of pink deposits have enabled me to distinguish, in cases of abdominal tumours, their connection or want of relation to the liver or spleen.

186. This opinion of the pathological indications of purpurine, which I have now for some years supported and taught in my lectures at Guy's Hospital, received important confirmation from the researches of Professor Scherer,[140] of which mention has already been made (102). This excellent chemist* observed that when a person in good health is confined to a diet nearly free from nitrogen, active exercise being avoided, the quantity of carbon and hydrogen excreted in the urine is always at a maximum. In fever, or where metamorphosis of tissue (31) is actively going on, in addition to the abundance of nitrogenized products eliminated in the urine by the kidneys, a pink pigment, very rich in carbon, communicating the well-known tint to the secretion, also exists. This state of

* I trust I may not be considered too egotistic in remarking that the opinions above expressed of the function of the pink pigment, as well as the use of the hydrochloric acid test for its detection, are original with myself. They were the result of careful clinical observation, and were announced in my lectures, delivered at Guy's Hospital in 1841-2, afterwards reported in the 'Medical Gazette.' A long review of these lectures was given by Professor Scherer himself, in Canstatt's 'Jahres-bericht,' for 1843, in which he translated the account I had given of the hydrochloric acid test, and of the supposed function of purpurine. So that he must have been well acquainted with my own observations made four years before the announcement of his own much more elaborate researches.

things always occurs, and affords a ready explanation of the characteristic high colour of febrile urine, unless a great diminution of water or some other cause exist to explain it. Scherer found the following proportions of carbon and hydrogen in the pigment of urine of a case of hectic, and two cases of typhus fever:

	Hectic fever.	*Typhus fever.*	*Typhus fever.*
Carbon . .	65·25 . .	64·43 . .	62·80
Hydrogen . .	6·59 . .	6·30 . .	6·39
Oxygen and nitrogen	28·16 . .	29·27 . .	30·81

Indeed, in every case the presence of an excess of a highly carbonized pigment, independently of any deposit, as shown by the test of hydrochloric acid and heat, may be regarded as a satisfactory indication of a lesion of function of one of the great normal emunctories of carbon, especially the lungs and liver. The presence of this matter in the urine is, therefore, to be regarded as an evidence of the kidneys performing a compensating function for the lungs or liver.

187. It is a curious fact, and one which strongly substantiates the accuracy of this opinion, that the colouring matter of bile often coexists with this carbonized colouring matter or purpurine. This may, often where scarcely suspected, be detected by collecting the precipitate produced, by adding di-acetate of lead to the urine, on a filter, and boiling it in alcohol acidulated by hydrochloric acid. The bile-pigment will dissolve, forming a green solution. Another remarkable corroboration of this opinion is afforded by the analogy in composition existing between the carbonized colouring matter of urine (purpurine) and the bile-pigment (biliphœin) so frequently met with in urine in cases of jaundice, and easily recognised by proper tests (61). This pigment may be obtained

by precipitating it from urine by chloride of barium, and digesting the precipitate in alcohol, acidulated by sulphuric acid. The following is a view of the chemical composition of the colouring matters under consideration :

	Normal colouring matter of urine.	Urinary colouring matter in jaundice.	Urinary colouring matter in organic disease of the liver.	Bile-pigment from urine.
Carbon . .	58·43	60·19	65·76	68·182
Hydrogen .	5·16	6·66	6·01	7·437
Nitrogen . .	8·83	} 34·25	} 28·23	7·074
Oxygen . .	27·58			17·261

CHAPTER VII.

CHEMICAL PATHOLOGY OF CYSTINE.

(*Cystin-uria.*)

History, 188—Diagnosis of cystine, 189—Liebig's test, 190—Characters of urine depositing it, 191—Spontaneous changes in cystine, 193—Microscopical character of, 194—Simulated by chloride of sodium, 196—Pathological origin, 197—Probable connection with struma and imperfect state of hepatic functions, 199—Therapeutical indications, 200.

188. This substance was first discovered by Dr. Wollaston in a calculus given him by Dr. Reeve, of Norwich. It does not exist as an ingredient of healthy urine, and rarely occurs as an element in the diseased secretion, although it is probable that the sulphur-extractive (103) of urine may bear some relation to this substance, possibly indeed being the source from which it is derived. Its chemical composition is extremely remarkable, as it contains no less than 26 per cent. of sulphur. Cystine has been found in urinary sediments by very few observers, and it was not recognised in this form until a long period after its discovery in calculi.

189. *Diagnosis of cystine.*—This substance, when present in the urine, forms a nearly white or pale fawn-coloured pulverulent deposit, much resembling the pale variety of the urates (130). The greatest proportion of

it appears to be merely diffused through the urine whilst in the bladder, as at the moment of emission the secretion is always turbid, and very soon deposits a very copious sediment. I have seen a six-ounce bottle full of urine let fall by repose a sediment of cystine of the height of half an inch. On applying heat to the urine, the deposit undergoes no change, and very slowly dissolves on the subsequent addition of hydrochloric or nitric acid. Pure cystine is soluble in the mineral and insoluble in the vegetable acids; with the former it forms imperfect saline combinations, which generally leave by evaporation gummy masses or acicular crystals. It is readily soluble in ammonia and the fixed alkalies and their carbonates, but insoluble in carbonate of ammonia. Heated on platina foil it burns, evolving a peculiar and disagreeable odour.

A deposit of cystine may be distinguished from one of white urates, by not disappearing on warming the urine, and from the earthy phosphates, by being insoluble in very dilute hydrochloric or strong acetic acid. The best character of cystine is its ready solubility in ammonia, mere agitation of some of the deposit with liquor ammoniæ being sufficient to dissolve it, and a few drops of the fluid, when allowed to evaporate spontaneously on a slip of glass, leaves six-sided tables of cystine (194). The ammoniacal solution, when kept for some time in a white glass bottle stains it black, from the combination of the sulphur of the cystine with the lead in the glass.

190. Another test has been proposed by Liebig,[60] founded on the presence of sulphur; he directs the deposit suspected to contain cystine to be dissolved in an alkaline solution of lead, made by adding liquor potassæ to a weak solution of acetate of lead until the oxide at first thrown down is re-dissolved. On heating the mix-

ture, a black precipitate of sulphuret of lead appears if cystine be present. All sulphuretted animal matters similarly treated yield black precipitates, and hence this test is useless if any portion of albuminous or mucous substances, or of bile, are mixed with the deposit to be examined. If cystine exist, mixed with urates or phosphates, in a deposit, it is easily discovered by a few minutes' digestion with ammonia; and the evaporation of a few drops of the fluid, as already mentioned, leaves the characteristic crystals. This process is not liable to the fallacy of Liebig's test. Cystine has never been artificially formed; some fruitless attempts have been made to effect this by treating albumen with the sulphuret of potassium. The internal administration of sulphur does not appear to induce its formation, for I have repeatedly examined the urine of patients who were taking sulphur in large quantities, without detecting it.

191. *Character of urine depositing cystine.*—Most of the specimens of this variety of urine that I have met with, were pale yellow, presenting more of the honey-yellow than the usual amber tint of urine, not unfrequently possessing a somewhat oily appearance, like diabetic urine. The specific gravity of cystic urine is generally below the average, and is sometimes passed in larger quantity than natural. In one case (a child), in which Dr. Willis[61] met with cystine, the urine was of a specific gravity of 1·030; but this is certainly unusual. It is often neutral, less frequently acid to litmus paper, but soon becomes alkaline by keeping.

The odour of this form of urine is very peculiar, bearing in general a close resemblance to that of sweet-briar, and is sometimes rather powerful; less frequently the odour is fetid, like putrid cabbage, owing, I suspect, to

partial decomposition and evolution of sulphuretted hydrogen. In such specimens the colour has usually changed from pale yellow to green. In one case that occurred to me, the urine was actually of a bright apple-green; it presented this tint for a few days, and the specimens subsequently voided were yellow.

Cystic urine, on being kept for a short time, has its surface covered with a greasy-looking pellicle, consisting of a mixture of crystals of cystine, and ammonio-phosphate of magnesia. I have frequently observed it to undergo a kind of imperfect viscous fermentation in warm weather, bubbles of gas being evolved, and the whole becoming ropy and rather viscid (349).

A certain portion of cystine exists in solution in the urine, as the addition of acetic acid always precipitates a small quantity. When a case of this disease is carefully watched, and the urine repeatedly examined, the deposit will often be found to vanish for days together; but crystals of cystine are even then generally precipitated by acetic acid. The urea and uric acid are present in very small quantities, and in some specimens the latter is nearly absent. I found a specimen of urine passed by a boy from whom a cystine calculus had been removed a short time previously by my late colleague, Mr. Aston Key, to consist of—

Water	974·444
Solids	25·556
Urea (impure)	5·7
Uric acid	·016
Cystine	·340
Extract containing the fixed salts . .	19·5

192. In another case of a patient under the care of Dr. Shearman, of Rotherham, who has entered with great

zeal and success into these inquiries, I found a fluid ounce of the urine to yield, on evaporation, fifteen grains of solid matter, consisting of—

Uric acid	0·2
Urea	3·7
Cystine, Creatinine, Extractives	8·1
Earthy phosphates	0·2
Alkaline phosphates and sulphates and chloride of sodium	2·8
	15·

This urine deposited a tolerably copious sediment of crystallized cystine, but did not possess the peculiar sweet-briar odour. It was passed by a delicate strumous child who was the subject of severe pneumonia.

193. Calculi composed of cystine are generally pale yellow or fawn coloured, but by long keeping they undergo some change, and assume a greenish-gray, and sometimes a fine greenish-blue tint. The specimens described by Dr. Marcet in 1817, and existing in the museum of Guy's Hospital, were at that time pale brown; they now possess a colour resembling that of green sulphate of iron, which hue they have, to my knowledge, presented for the last twenty years. A similar change of colour has been observed by Dr. Peter in two cystine calculi preserved in the medical museum of Transylvania University. He observed that the change commenced on that side of the concretion which was exposed to the light. This change of colour in the concretions, as well as in the urine, before alluded to, is probably owing to some change in which the evolution of sulphur is an element.

194. *Microscopic characters of cystine.*—These are so well marked and easily recognised, that the microscopic examination of a sediment composed of cystine, renders the application of tests almost unnecessary.

When an ammoniacal solution of cystine is allowed to evaporate spontaneously on a piece of glass, it leaves crystals in the form of six-sided laminæ (fig. 37). These are probably exceedingly short hexagonal prisms. When the evaporation is slowly and carefully performed,

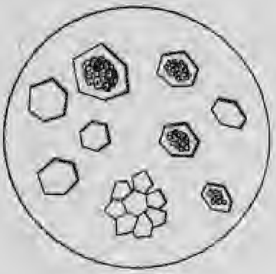

Fig. 37.

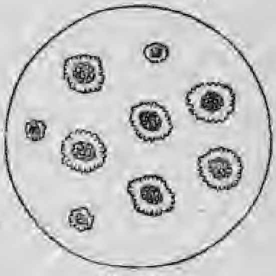

Fig. 38.

these laminæ are transparent; but in general they are crystallized in a confused and irregular manner in the centre, the margins only being perfectly transparent. When examined by polarized light, these crystals, when sufficiently thin, present a beautiful series of tints, which are not observed when thick, on account of the high refracting power of cystine.

195. When cystine occurs as a sediment, it is always crystallized, never under any circumstances being amorphous. Among the crystals a few regular six-sided laminæ are often seen, but the great mass is composed of a large number of superposed plates, so that the compound crystals thus produced appear multangular, as if sharply crenate at the margin; and the whole

surface is traversed by lines, which are really the edges of separate crystals (fig. 38). They thus resemble little white rosettes when viewed by reflected light. These compound crystals always appear darker in the centre than at the circumference, which is sometimes quite transparent. Prisms of the triple phosphate (264) are often mixed with the cystine, but on the addition of a few drops of acetic acid, they readily dissolve, leaving the rosettes of cystine unaffected.

196. A fallacy may possibly arise in the detection of cystine under the microscope, by the evaporation of the urine, and crystallization of the chloride of sodium or common salt. The salt naturally crystallizes in cubes, but assumes an octohedral figure if urea be present. If, however, a small quantity be allowed to crystallize spontaneously from its solution in urine, it forms minute transparent crystals, which present generally a three, four, or six-sided outline (fig. 39), according to the position in which they happen to lie on the glass, and might at first be mistaken for plates of cystine. Their

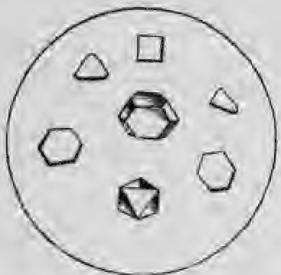

Fig. 39.

Fig. 40.

solubility in water, and absence of all colour when examined by polarized light, will prevent these crystals from

being mistaken for cystine. If urine containing common salt be hastily evaporated on a slip of glass, the regular transparent octohedrons are not met with, being replaced by a series of elegant crystals, shaped like crosslets and daggers (fig. 40). The appearance of these, on the evaporation of a fluid containing a little common salt, is a tolerably safe indication of the presence of urea. Uric acid also occasionally assumes the form of hexagonal tablets, but may be distinguished by the absence of the superficial marking.

197. *Pathological origin and indications of cystine.*—This curious substance is, in all probability, a derivative of albumen, or of structures into which it enters, and appears to be the result of derangement of the secondary assimilative processes (39), essentially connected with the excessive elimination of sulphur; every ounce of cystine containing more than two drachms of this element. A question may be entertained whether cystine may not be a metamorphic form of the normal sulphur-extractive of the urine, or the condition assumed by this extractive when an excess of sulphur is eliminated. From an examination of its chemical composition, there appears no difficulty in explaining the origin of cystine, by supposing that it is formed by those elements of our tissues which would normally have been converted into urea and uric acid (38), in consequence of the presence of an excess of sulphur; probably connected essentially with a scrofulous diathesis. Cystine consists of C_6, N, H_6, O_4, S_2.

	C N H O S		C N H O S	
1 atom urea .	2+2+ 4+2+0	=		
1 „ uric acid	10+4+ 4+6+0		12+2+12+8+4	=2 at. cystine.
1 „ sulphuretted hydrog.	4 4		4	=4 at. nitrog.
	12+6+12+8+4		12+6+12+8+4	

198. Although but little is known of the pathological condition of the system which induces the formation of cystine, there is sufficient evidence before us to justify our expressing a strong opinion of its essentially scrofulous and remarkably hereditary character. In one family alone several members were nearly at the same time affected with cystin-uria; and one instance exists in which it can be traced, with tolerable certainty, through three generations. In one well-remarked case, which fell under the care of Mr. Luke, at the London Hospital, extensive disorganization of the kidneys co-existed with a cystine calculus. There is, probably, a remarkable deficiency of the process of oxidation in these cases; Dr. Prout has even seen fatty matter mixed with the urine, and suggests the probability of its connection with fatty liver. And this opinion seems to be by no means improbable, especially when we regard the close approximation that exists between the elementary composition of cystine and taurine, the crystallized substance into which bile is partly converted by digestion with hydrochloric acid. The following is a comparative view of the per-centage compositions of cystine and taurine:

	Cystine.	*Taurine.*
Carbon	30·000	19·2
Hydrogen	5·000	5·6
Nitrogen	11·000	11·2
Oxygen	26·667	38·4
Sulphur	26·667	25·6

So that it appears by no means unlikely that the excretion of cystine may be a means, under certain circumstances, of compensating for deficient action of the liver *quoad* the excretion of sulphur. It appears that the sulphur discovered by Redtenbacher in taurine, was, by former

chemists, confounded with oxygen, as was the case in the earlier analyses of cystine.

199. Dr. Shearman has been kind enough to send to me specimens of the cystine he discovered in the urine of chlorotic females—a very interesting circumstance in connection with the probable general deficiency of oxidation existing in this affection. In a communication from the zealous and excellent physician alluded to, he mentions the following particulars:

Some urine passed by a chlorotic girl, after being mixed with ammonia, and set aside in a white phial, evolved in a few days sufficient sulphuretted hydrogen to stain the glass black. When fresh, the urine had a very peculiar odour, and deposited a white sediment unaffected by acetic or hydrochloric acid, but soluble in ammonia. The solution left, by evaporation, six-sided laminæ, which, in all their microscopical and optical properties, resembled cystine.

Two specimens of urine exhibiting these characters were passed by two sisters; a third was obtained from a girl belonging to another family. I am convinced that the urine in many cases of depressed health, in strumous patients especially, not very unfrequently contain crystals of cystine, not sufficiently abundant to form a distinct deposit, but still obvious enough on microscopic examination.

200. *Therapeutical indications.*—These are unfortunately in the present state of our knowledge not very well understood. The cases in which a moderately large quantity of cystine exists, have been observed too seldom to allow of any accumulation of experience, and most of them having occurred in private practice, have precluded that minute and persistent watching which is so necessary for satisfactory information. The most important indi-

cations are to correct the unhealthy condition of the assimilative functions, and if possible to render the cystine, so long as it continues to be formed, soluble in the urine. To effect the latter, the persistent use of nitro-hydrochloric acid has been recommended by Dr. Prout, and in some cases with success. In my hands I must confess it failed in either dissolving the deposit, or preventing its formation. The general health should be most carefully attended to, and everything interfering with it removed as completely as possible. Sea-bathing, exercise, nutritious and digestible diet, with attention to the functions of the skin, promise to do much. I feel inclined to place great confidence in the use of iron, especially of the syrup of iodide of iron, in doses of ʒss to ʒj immediately after each meal. Unfortunately, as in all ailments demonstrably hereditary, we have an obstinate disease to treat, and the prognosis must be extremely guarded, as in the majority of cases the generation of cystine goes on to the formation of a calculus.

CHAPTER VIII.

CHEMICAL PATHOLOGY OF HIPPURIC ACID.

(*Hippuria.*)

History, 201—Diagnosis of hippuric urine, 202—Process for the detection of the acid, 203—Microscopic characters, 204—Pathological origin of hippuric acid, 205—M. Bouchardat's case of hippuria, 206—Dr. Garrod's case, 207—Dr. Pettenkofer's case, 208—Hippuria traceable to imperfect assimilation of carbon, 209.

201. HIPPURIC acid is very generally present in the urine of herbivorous animals, and is indebted for its present appellation to its constant occurrence in the urine of the horse. Rouille, as long as seventy years ago, described it as occurring in the urine of graminivorous mammals, but mistook it for benzoic acid. Scheele, and subsequently Fourcroy, Reynard, and Proust, demonstrated its existence in the urine of young infants. Lehmann and Ambrosiani announced its presence in diabetic urine, and still more recently it has been proved by Professor Liebig to be a constant element in the healthy secretion, although in so small quantity as to escape detection (8) except by a very careful and tedious chemical analysis.

202. *Diagnosis of urine containing an excess of hippuric acid.*—As this substance never, so far as is yet known,

appears in the form of a sediment until after the addition of a stronger acid, our diagnosis must entirely depend upon the characters of the urine containing it.

Urine containing an excess of hippuric acid is generally either very slightly acid or neutral, often alkaline. Its characters can be best studied in the urine of a cow or calf, as the copious deposit of carbonate of lime, as well as its viscidity, make the horse's urine a more difficult object for examination. When the presence of hippuric acid is directly traceable to the ingestion of benzoic acid, an exception to the above characters is met with, the urine then being acid, often remarkably so, which, I believe, is never the case when hippuric acid occurs independently of the administration of cinnamic or benzoic acids. The odour is generally like that of whey, and the specific gravity, so far as has been yet observed, below rather than above the healthy average, varying in M. Bouchardat's case (206) from 1·006 to 1·008. Deposits of the triple phosphate of magnesia are by no means unfrequent in such urine. A drop of neutral or alkaline hippuric urine, as that of the calf, when allowed to evaporate spontaneously on a glass plate, leaves delicate feathers of hippurate of ammonia, very distinct in appearance from any crystals I have seen from any other variety of urine.

208. To detect the presence of an abnormal proportion of hippuric acid, fill a large watch-glass with the urine, and evaporate it over a lamp to a few drops, then add about half the bulk of hydrochloric acid, and set the mixture aside. On the addition of the acid, the mixture becomes bright pink, and a pungent odour, not unlike that of new hay, is evolved. After a few hours, examine the contents of the watch-glass, and if an excess of hippuric acid be present, its characteristic

linear crystals will be observed. These almost always assume a very remarkable form, like a bunch of leafless twigs, cohering with sufficient firmness to allow of their being washed and dried in this position (fig. 41 *a*). The watch-glass should not be emptied for twenty-four hours after the first addition of the acid, for sometimes the crystals form very slowly, owing to their solubility in the precipitant. The glass should be examined under the microscope, and delicate, slender, often branched, crystalline needles of hippuric acid, which may escape the naked eye, may thus be detected (fig. 41 *b*). Sometimes so much hippuric acid is present, that, if sufficient time be allowed, crystals of it appear without any previous evaporation. This is well seen in the urine of the horse, especially when obtained after being well fed, and resting all day in the stable. It is quite certain, however, that a considerable quantity of hippuric acid may be present and yet escape detection by this process, in consequence of the urea interfering with its crystallization. From very careful experiments, I find that when the acid exists in less quantity than one grain in the fluid ounce of urine, it cannot be thus detected. In this case we must have recourse to the process before described for the preparation of the acid from the healthy urine (96).

Fig. 41.

204. *Microscopic characters of hippuric acid.*—If crystals are obtained by the modes just described, all possible doubt of their real nature may be removed by dissolving a portion in alcohol and another portion in hot water.

On placing a drop of these solutions, when cold, on plates of glass, beautiful crystals, some possessing a dendritic and plumose outline, others arranged like zeolites, will be left by the spontaneous evaporation of the alcoholic solution (fig. 42), and minute needles, mixed with

Fig. 42.

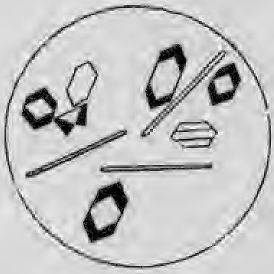

Fig. 43.

four-sided prisms acuminated at their ends, will be formed from the watery solution (fig. 43). On heating some of the crystals in a glass tube until they begin to char, they evolve a very characteristic odour of the Tonquin bean.

All these characters may be observed, and the crystals readily obtained from the urine passed by a person an hour or two after swallowing 10 grains of benzoic acid.

Both the hippuric and benzoic acids will disappear from the urine of over-driven animals. I could not detect a trace of either in the urine of an ox which had been driven up from the country to Smithfield and killed a few hours after. Neither of these acids was found by Boussingault in the urine of pigs, even when their food was varied. The large amount of carbon appropriated by these animals in their enormous accumulations of fat,

probably interferes with any considerable excretion of this element by the kidneys.

205. *Pathological origin and indications of hippuric acid.*—This part of our subject is enveloped in much obscurity. All that is known with certainty of the matter may be thus stated:

A. Hippuric acid appears to be peculiar to vegetable feeders, and to be most constant in those which take little or no exercise. Thus it abounds in stall-fed cattle, and disappears, being replaced by benzoic acid, in those that are worked; a fact explained by the larger proportion of carbon and hydrogen existing in hippuric as compared to benzoic acid. The former contains 18, and the latter 14 atoms of carbon in each equivalent.

B. When in excess in human urine, it has been generally traceable to peculiarities of food. In one case connected evidently with a long confinement to a milk diet (206); in another, to the almost exclusive use of apples (208). Its occasional (but by no means constant) occurrence in the urine of infants at the breast is, in all probability, traceable to their mal-assimilating the large quantity of carbon contained in the food.

C. It does not necessarily interfere, at least in man, with the production of uric acid; for although the latter is occasionally absent, yet not so constantly as to lead to a belief that hippuric and uric acids do not replace each other.*

* *Vide* (98) note.

D. In general a deficiency of urea occurs in hippuric urine. It appears nearly proved that the elements of glycocoll or sugar of gelatine (C_4, N, H_4, O_3), by the presence of which hippuric differs from benzoic acid, are derived either from urea or from nitrogenized matter, which would, under ordinary circumstances, have formed this substance.

206. The following case, in which albumen coexisted with hippuric acid, is recorded by M. Bouchardat:

Madame G—, æt. 53, the mother of one child, residing in the country, possessing good general health, and in easy circumstances, ceased to menstruate at the age of 45. After this period she became frequently the subject of a severe obscure hepatic and intestinal affection, which, as her convalescence was protracted, led to her being placed on a milk diet. She kept to this for nine years, and her health became re-established. Her general diet consisted of coffee, with a pint of milk, and five ounces of bread, for breakfast. For dinner, soup-maigre or graisse, with two ounces of meat, and about five of vegetables, and as much of bread, taking wine and water for drink. In the evening she took merely a pint of milk. This lady's health again gave way; there was great lassitude and much indisposition to exertion, with absence of all perspiration, which, for the preceding nine years, had been profuse. Skin harsh and almost scaly. Vague pains in the region of the liver, with a jaundiced tint of the surface. Fæces black. Mouth dry, with a disagreeable taste. Headache and tinnitus aurium; vision imperfect. The night passed in broken slumbers. Palpitation of heart, accompanied with an anœmic murmur in the carotids, and a rapid pulse. Slight œdema of the lower extremities towards evening. For months previously she had become the subject of partial paralysis of the right side, which disappeared on depletion. Lungs healthy, although the subject of occasional dyspnœa. The most prominent symptoms of all were, however, increased bulk of the urine, and thirst, often drinking six to ten pints of water in the day.

Character of the urine.—Limpid, with a whey-like odour. Sp. gr. 1006-8, acid, slightly coagulable by heat. On evaporating the urine to a small bulk and adding hydrochloric acid, the hippuric acid crystallized on cooling. Uric acid was absent. The urine consisted of—

Water	985·46	
Solids	14·54	
Urea		1·56
Hippuric acid		2·23
Albumen		1·47
Fixed salts		5·28
Organic and volatile combinations		4·
		14·54

This patient ultimately sank exhausted.

207. The second case occurred to Dr. Garrod, to whom I am indebted for the following brief account of it:

The subject of this affection was a young man, æt. 23, who in September, 1842, became a patient of Dr. Garrod's for general malaise, accompanied by the excretion of an excess of urea in his urine, and the deposition of ammoniaco-magnesian phosphate, from which, under the use of opiates with nitric acid, he recovered. A few months subsequently he suffered from an attack of atonic dyspepsia, with pain in the loins. On adding some hydrochloric acid to the urine for the purpose of precipitating uric acid, long crystals of hippuric acid were formed, and on these the uric acid was slowly deposited. This condition of urine continued for several days, half a pint yielding as much as 40 grains of hippuric acid. The uric acid and urea existed in normal proportion. After a few days the hippuric acid decreased in quantity, so that the urine did not afford crystals on the addition of hydrochloric acid until concentrated by evaporation. In a short time the urine became normal. No information as to the source of the hippuric acid could be obtained from the history of the patient. He had lived on a mixed diet, and never used any excess of vegetable food, nor had he ever taken any benzoic acid.

208. The third, and perhaps most interesting case, is the following, and was published by Dr. Pettenkofer, who examined the urine:

A girl, æt. 13, admitted in January, 1844, with chorea, into the Julius Hospital of Wurzburg, under the care of Dr. De Marcus. She had been long the subject of chorea, complicated with anomalous hysteric symptoms. Prior

to her admission she refused to take any other food than apples, with bread and water, upon which she had for some time entirely subsisted. The urine was yellow, limpid, and faintly acid when first passed, soon becoming alkaline, and depositing crystals of triple phosphate of magnesia. The addition of hydrochloric acid to it after moderate concentration, produced a copious formation of crystals of hippuric acid. The addition of nitric acid, by its oxidizing influence, caused the deposit of hippuric to be replaced by one of benzoic acid. In 1000 parts of the urine there were—

Water	959·332	
Solids	40·668	
	1000·	
Solids soluble in alcohol . . .		18·451
„ insoluble in alcohol . . .		9·417
Anhydrous hippuric acid . . .		12·800
		40·668

Fixed salts containing much carbonate of soda 10·599.

The characters of the urine in this case approached those of an herbivorous animal in the presence of hippuric acid and of carbonate of soda in the ash, as well as in the absence of uric acid.

The hippuric acid disappeared, and the urine assumed its normal proportions on inducing the girl to return to a mixed diet.

209. From what little experience we possess regarding hippuria, it appears pretty certain that the existence of this condition of the urine is generally connected with the use of a diet deficient in nitrogen, or in the malassimilation of the carbon of the food. Its following temporarily the use of benzoic acid, its occurring after the use of nearly exclusively vegetable food (208), or of a milk diet, as shown in Bouchardat's case (206), as well as in infants at the breast, all help to prove the former proposition. I do not know enough of Dr. Garrod's case (207) to be able to state how far this might be regarded as an example of the second condition. If the functions of the liver *quoad* the depurating influence of

the gland, were imperfectly performed, we should possess a probable solution of the cause of the presence of hippuric acid in the urine. When we regard the composition of hippuric acid (98), and call to mind the fact of its occurring in stall-fed cattle, and its being replaced by an acid less rich in carbon in animals taking much exercise, we cannot avoid arriving at the conclusion that hippuric acid may be one of the agents by which the kidneys perform a vicarious function for the liver in removing an excess of carbon from the system.

In this respect, hippuric acid probably performs an analogous function to purpurine and bile-pigment (187), each being respectively competent to the removal from the system of 63·93, 62·0, and 68·182 per cent. of carbon, and 4·6, 6·2, and 7·437 per cent. of hydrogen.

210. My own experience in these cases has been too limited to justify my offering any opinion on the pathological complications attending them. From what little I have observed, I feel inclined to believe that when an excess of hippuric acid exists, it may always be regarded as traceable to, and pathognomonic of, the deficient function of the liver, lungs, or skin, the great emunctories of carbon; or to the use of food deficient in nitrogen. It hence follows, that our treatment will consist in appealing to the function at fault, and carefully regulating the diet.

I would suggest the propriety of seeking for the presence of hippuric acid in the urine, where it is copious, of low specific gravity, but slightly acid or neutral, and occurring in persons who have a dry and inactive state of surface with anæmia. In many pseudo-chlorotic cases in both sexes, I am inclined to believe an abnormal proportion of this acid will often be met with.

CHAPTER IX.

CHEMICAL PATHOLOGY OF OXALATE AND OXALURATE (?) OF LIME.*

(*Oxaluria.*)

History, 211—Long overlooked, 213—Diagnosis of oxalate of lime, 214—Microscopic forms of, 215—Oxalurate of lime, 219—Relation of oxalic to oxaluric acid, 221—Uric acid erroneously described as oxalate of lime, 222—Dr. Bacon's researches, 223, 225—Characters of urine depositing the oxalate, 227—Presence of epithelium and excess of urea, 228—Complication with other deposits, 229—Pathological origin of the oxalate of lime, 232—Absence of sugar in oxaluria, 233—Oxalate of lime in the blood, 235—Formation of oxalic acid from urea and uric acid, 237—Derivation of oxalic acid from vegetable ingesta, 240—Oxalate in mucous secretions, 241—Symptoms of oxaluria with excess of urea, 243—without excess of urea, 245—Exciting causes of, 248—Therapeutical indications, 249—Illustrative cases, 252.

History.

211. Oxalate of lime is so frequently present in the urine, is so often a constituent of one of the most

* The subject of this chapter has been so well handled by the author, and the objections raised against it have been either so completely answered or anticipated, that I should have considered further discussion unnecessary, were it not that its principal opponents, among whom we must class Lehmann, Scherer, Dr. Bence Jones, and Dr. Owen Rees, were men of distinguished ability and scientific acquirements. We must, however, be guided by reason,

annoying forms of calculous concretions, and is so generally important in its p .thological bearings, that it

not led by authority. Lehmann observes: "With reference to the occurrence of oxalate of lime in certain morbid conditions, Prout, Bird, and others make very different statements, none of which are yet fully established: numerous examinations have convinced me that in this country, at least, the sediments of oxalate of lime are much rarer than they are represented to be by English writers. These observations have led to the following result; when the respiratory process is in any way disturbed we most frequently observe a copious excretion of oxalate of lime. . . . In the dyspeptic conditions in which Prout and Bird have found sediments of oxalate of lime, I have failed in discovering anything of the sort; on the contrary, I have found the sediments in the urine of such patients to be free from these crystals. The reason why the English have so often found this salt in the urine, may be that in England the urine is generally in a more concentrated state than in Germany, and, as Bird very correctly remarks, oxalate of lime is more rapidly separated from a concentrated than an aqueous urine: moreover, experience at the bedside teaches every unprejudiced observer that the appearance of oxalate of lime in the urine is by no means accompanied by the groups of symptoms which certain English physicians describe as pertaining to what they call the oxalic diathesis. . . . It seems, moreover, unreasonable to set up such a diathesis; since the establishment of a special disease from a single symptom—that symptom being only the occurrence of oxalate of lime—is entirely opposed to the spirit of rational medicine. From Wöhler and Liebig's discovery that uric acid is decomposed by peroxide of lead into urea, allantoin, and oxalic acid, it has been pretty generally assumed that the oxalic acid of the urine is due to an oxidation of the uric acid; the oxalic acid in this case not being converted into carbonic acid, as usually occurs in the healthy organism."

Scherer accounts for the oxalate of lime in the urine by considering it due to decomposition during the acid fermentation, and explains the process on the supposition that the mucus of the bladder is a fermenting body, and that the extractive pigment is the substance metamorphosed into lactic acid. Dr. Owen Rees, in his lectures before the College of Physicians, depends mainly on Scherer's views in his argument in opposition to the existence of the oxalic diathesis, and ingeniously rejects many of the author's cases, for the reason that the heat which was applied to the urine might itself have been the cause of the formation of oxalate of lime from decomposition. Dr. Bence Jones observes: "Oxalate of lime is so frequently found in the urine of those who are in perfect health, that I do not consider it as indicating any disease, but only a disorder of no serious importance. It scarcely indicates a

merits especial attention, and I am now particularly anxious to allude to the importance of carefully studying

more serious derangement of the general health than a deposit of urate of ammonia does. It may be found in the urine of all who lead sedentary lives, taking insufficient air and exercise, and more food than is requisite for the daily wants of the system."

This constitutes the case of the opponents of the existence of such a disease as oxaluria, or such a diathesis as the oxalic acid diathesis. The arguments on the other side may, for the most part, be found in or gleaned from the previous editions of this work. 1st. It is not denied that oxalate of lime may, and frequently does occur, in the urine of persons enjoying good health; and Lehmann himself correctly says the same of sugar; viz., that it is the quantity of sugar that is present which constitutes the characteristic symptoms of diabetes mellitus.* Yet he does not deny the existence of diabetes. 2d. Oxalate of lime may be formed in the urine *after* removal from the body, and its formation *may* be favoured by the application of heat; but the crystals of oxalate of lime are, nevertheless, found in *fresh* urine, and do not necessarily require the application of heat for their detection; indeed I never myself use heat for this purpose, and yet I have seldom failed to detect the octohedral crystals in cases where the symptoms have led me to look for them. 3d. That the oxalate of lime may be held in solution in the urine, and afterwards deposited, as the causes determining its solution cease to exist; therefore its non-detection in the freshly passed urine is no proof of its absence, but only of its non-deposition. The case of those opposing the existence of oxaluria is argued from the occurrence of the crystals in the urine up to the supposed constitutional derangement, instead of from the constitutional derangement to the urinary deposit; and this step in the argument takes the following form. A certain group of symptoms, distinctly marked, and consequently easily recognised, constituting a form of dyspepsia, but differing in many respects from that of gout, is almost universally accompanied by the passing of urine containing oxalate of lime; and this position has never as yet been shaken. It is a matter of indifference whether the disease be named oxaluria, or dyspepsia with a tendency to the formation of oxalic acid, *i. e.*, oxalic dyspepsia. It may by some be considered improper to name a disease from a single symptom, but if that symptom be constant, constituting the *differentia* of the disease, it matters little, as far as science is concerned, whether the *differentia* be taken alone, or in connection with its *subject*, in the name, as long as the definition of the disease be full and accurate.

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* Vol. ii, p. 427.

the relations of this form of deposit to certain states of health, because it seems now to run some risk of being tossed aside as a thing of no consequence. A curious revulsion of feeling seems to have taken place, among some at least, on this subject. When I first discovered oxalate of lime as a crystalline deposit, and announced its frequency, my observations were doubted by many, and whenever they were favoured with any attention, they were always distinctly stated to rest exclusively on my authority. Now that more extended observations have demonstrated the truth of my statements, we are told, both in this country and abroad, that oxalate of lime is of constant occurrence, and of no importance. A remark to which too many sufferers from this diathesis can give a melancholy denial.

212. The supposed extreme rarity of crystalline deposits of oxalate of lime in the urine had often attracted the notice of writers on calculous affections, and many had expressed their surprise that, although they had repeatedly examined the urine in cases where calculi of oxalate of lime exist, they had not succeeded in detecting a deposit of this substance. To the generally admitted accuracy of this statement all investigators had borne witness; thus, in the third edition of the elegant and elaborate work of Dr. Prout, which must be regarded as giving the most complete account of the state of our knowledge on these matters at the time it was published (1840), the deposit of oxalate of lime was scarcely described. The remarks there made on the oxalic diathesis applied to the cases in which the oxalate of lime has existed in a truly calculous form, or to those in which the presence of oxalic acid is rather suspected than proved;[62] the whole series of observations inclining to the generally received notion

of the almost necessary connection between the presence of saccharine matter and development of oxalic acid. M. Rayer alludes, on the authority of M. Donné, only to the artificial production of crystals of oxalate of lime, effected by administering to patients alkaline oxalates;[63] and figures, among his very accurate delineations of urinary deposits, the precipitate produced by the addition of oxalate of ammonia to urine. The only case of the occurrence of oxalate of lime in the urine that he cites is one which occurred to myself several years ago, the details of which appeared in the 'Medical Gazette,'[64] in a laborious paper on urinary deposits, by Dr. Brett. And this is also the only instance alluded to by Dr. Willis, in his interesting work on Urinary Diseases.

I was first led to question the accuracy of the generally received opinion of the extreme rarity of the presence of oxalate of lime in a crystalline form, during my examination of urinary deposits preparatory to the publication of an essay in the seventh volume of the Guy's Hospital Reports. Subsequently, in the extensive field of experience at my command, I pursued these researches on a large scale, and examined microscopically the urine in an immense number of cases of various diseases.[65] The result of this investigation led to the discovery of the comparative frequency of oxalate of lime in the urine in fine and well-defined octohedral crystals, and of the connexion between the occurrence of this substance and the existence of a certain series of ailments, generally characterised by nervous irritability. The accounts of my researches were published in the London Medical Gazette for 1842.

213. The reason of the oxalate having been overlooked so long is explained with great readiness, for

without the aid of the microscope it is utterly impossible to demonstrate its presence, so long as it is diffused through the urine in separate crystals. In the less frequent form of minute concretions or hemp-seed calculi, of course it is readily recognised, but such cases are as rare as the occurrence of the oxalate in separate crystals is common.

It will be a matter of great interest to investigate the comparative frequency of the oxalate of lime in the urine in different localities, for the purpose of ascertaining how far the formation of this salt is connected with the depressing influences always more or less active in large and densely populated cities; for, in the cases of disease occurring in the metropolis, I have no hesitation in declaring, as the result of my own experience, that the *oxalate is of far more frequent occurrence in the urine* than the deposits of earthy phosphates. And since the publication of the first edition of this work I have received repeated communications from provincial practitioners confirming this statement. Indeed I am convinced that traces of this salt in the minutest microscopic crystals can be detected in the urine of persons who are free from any apparent disease. Hence oxalate of lime must be regarded as one of the common results of metamorphosis of tissue, but the existence of the traces of the substance (which indeed may be regarded as a physiological condition,) is a very different thing from its presence in large crystals and considerable quantities, and which can be only deemed as existing under a state of system strictly pathological.

Diagnosis and microscopic characters of Oxalate and Oxalurate (?) of Lime.

214. To examine urine for the purpose of detecting the existence of the salt under consideration, allow a portion passed a few hours after a meal to repose in a glass vessel: if this be done in winter, or during the prevalence of frequent and rapid alternations of temperature, a more or less dense deposit of urates will generally make its appearance, arising either from the sudden cooling of the urine, or from interference with the functions of the skin prior to its excretion. In warm weather, however, or when the functions of the skin are tolerably perfect, the urine, albeit it may be really loaded with oxalate of lime, may still appear limpid, or, at furthest, its lower layers only be rendered opaque by the deposition of a cloud of vesical mucous. Decant the upper 6-7ths of the urine, pour a portion of the remainder into a watch-glass, and gently warm it over a lamp; in a few seconds the heat will have rendered the fluid specifically lighter, and induced the deposition of the crystals of oxalate, if any be present: this may be hastened by gently moving the glass, so as to give the fluid a rotatory motion, which will collect the oxalate at the bottom of the capsule. The application of warmth serves, also, to remove the obscurity arising from the presence of urates, which is readily dissolved on exposing urine containing it to a gentle heat (130). Having allowed the urine to repose for a minute or two, remove the greater portion of the fluid with a pipette, and replace it by distilled water.*

* It has been stated that the crystals of oxalate of lime, thus obtained, *may* be formed by the process of heating, and *may* not have existed, as such, pre-

A white powder, often of a glistening appearance, like diamond-dust, will now become visible, and this (under a low magnifying power, as by placing the capsule under a microscope furnished with a half-inch object-glass,) will be found to consist of crystals of oxalate of lime in beautifully-formed transparent octohedra, with sharply-defined edges and angles (Fig. 44).

215. If the light is very bright, these crystals generally resemble cubes marked with a cross, the point of intersection of the two arms corresponding to one of the apices of the octohedron (Fig. 45).

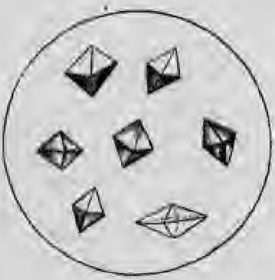

Fig. 44.

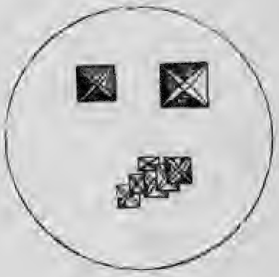

Fig. 45.

It sometimes happens that the oxalate is present in the form of exceedingly minute crystals: it then resembles a series of minute cubes, often adhering together

viously, in the urine; but even were this the case, it is ascertained that the process does not, in all instances, in which uric acid or urates are present, produce a similar result; hence in certain instances a modifying cause is present, which may be taken as evidence in favour of the existence of a distinct diathesis. It is, however, never necessary to have recourse to this process, the crystals are sufficiently clear without it; though it certainly offers to those unacquainted with the microscopical appearance, a ready means of obtaining good specimens.

like blood-discs: these, however, are readily and distinctly resolved into octohedra under a higher magnifying power. More rarely oxalate of lime assumes a somewhat different form, apparently being made up of a square prism, with a four-sided pyramid at each end (fig. 46) forming a dodecahedron. If the crystals be collected and ignited on platinum foil, oxalic acid is decomposed, and carbonate of lime left; the subsequent addition of dilute nitric acid dissolves the residue with effervescence.

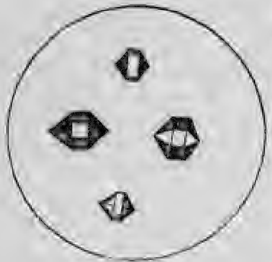

Fig. 46.

This is by far the most satisfactory process for the detection of oxalate of lime, and although it requires a little tact, still, after some trials, it can readily be performed in a very few minutes. But even this little waste of time may be avoided, by placing a drop of the lowermost stratum of the urine on a plate of glass, placing over it a fragment of thin glass or mica, and then submitting it to the microscope: the crystals diffused through the fluid becoming very beautifully distinct (123). In this way, however, it is obvious that a very much smaller quantity is submitted to examination than by the former process.

216. It is a very remarkable and interesting circumstance, that this salt, although I have now examined a very large number of specimens of urine containing it, has scarcely ever occurred to me in the form of a distinct deposit; remaining for days diffused through the fluid, even when present in so large a quantity that each drop of the urine, when placed under the microscope was found loaded with the crystals. If, however, any sub-

stance, capable of constituting a nucleus, be present, the oxalate will be deposited around it, although scarcely in cohering masses, and invariably colourless and beautifully transparent. The only exception to this is met with in the large and fine octohedral crystals of the oxalate which I discovered in the urine of the horse.[130] These are slightly opaque, and possess a fine amber hue, constituting most beautiful microscopic objects. If, as occasionally occurs, a specimen of oxalic urine happen to contain an excess of triple phosphate, the crystals of this salt are found mixed with those of the oxalate. I have also found the octohedra beautifully crystallized on a hair accidentally present in the urine like sugar-candy on a string.

217. The fact of a large quantity of the oxalate, when present, escaping the eye is explained, I suspect, from its refractive power approaching that of urine; for whenever we meet with the specimen in which the salt has partially subsided, and replace the decanted urine by distilled water, the crystals often become readily perceptible to the unaided eye, resembling so many glistening points in the fluid. The oxalate of lime although absolutely insoluble in water must be soluble in urine, for its lustrous crystalline form sufficiently indicates the fact of its previous solution. Indeed, not unfrequently, even on the most careful examination, no traces of oxalate can be discovered in a specimen of urine recently voided, and yet after twelve hours' repose an abundance of this salt in even large crystals can be readily detected.

Lehmann has observed, when discussing Scherer's ingenious views on the acid fermentation of urine, that "oxalate of lime may possibly be formed or separated during this process, and that the close connection between the separation of uric acid and the formation of this salt is supported by the fact, that most samples of urine,

whether sedimentary or non-sedimentary, exhibit no trace of the presence of oxalate of lime, when examined under the microscope, as long as they are fresh, although some of the known crystals of oxalate of lime may be detected as soon as the uric acid crystals are formed; and, indeed, that the abundance of such crystals in morbid urine is proportioned to the rapidity with which acid fermentation is induced, and the consequent early deposition of free uric acid." Dr. Owen Rees — indorsing these views, and stating in addition that the process of warming the urine facilitates the *formation* of oxalate of lime — has questioned the existence of any special diathesis. These views I have in another place endeavoured to answer.

218. The crystals of the oxalate, when collected in the manner above directed in a watch-glass, are unaltered by boiling either in acetic acid (223-5) or solution of potass. In nitric acid they readily dissolve without effervescence. The solution may be very readily watched under the microscope. When the oxalate is allowed to dry on a plate of glass, and then examined, each crystal presents a very curious appearance, resembling two concentric cubes, with their angles and sides opposed, the inner one transparent, and the outer black, so that each resembles a translucent cube set in a black frame (fig. 47). This is best observed, unless the crystals are very large, under an half-inch object-glass; as with a higher power this appearance is lost. Oxalate of lime when artificially prepared by precipitation appears as an amor-

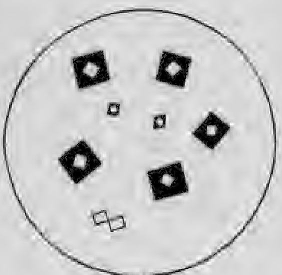

Fig. 47.

phous powder, but which under a high magnifying power can be resolved into myriads of minute crystals with a rectangular outline. Lehmann has stated, however, that a close imitation may be obtained of the urinary crystals in flattish octohedra by precipitating a very dilute solution of a lime salt at a boiling heat with oxalate of ammonia.

219. Occasionally some very remarkable crystals are met with, shaped like dumb-bells, or rather like two kidneys with their concavities opposed, and sometimes so closely approximating as to appear circular, the surfaces being finely striated. These crystals are produced, in all probability, by a zeolitic arrangement of minute acicular crystals (fig. 48), presenting a physical structure

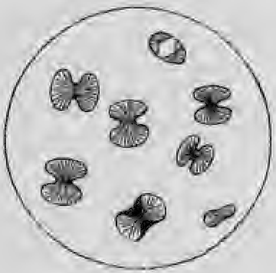

Fig. 48.

Fig. 49.

resembling that of spherical crystals of carbonate of lime.* We meet with many modifications of these ele-

* In the dumb-bell and oval crystals of oxalate of lime the markings are generally concentric; and there is some reason for supposing that crystals having radiating lines may consist of uric acid. Dr. Hassall has noticed ('Lancet,' 1850) certain modifications of the octohedron, and also of the

gant crystals, sometimes they are oval laminæ, in which no striæ or evidence of structure can be detected until they are examined by polarized light. In some of these a sort of nucleus can be detected. Some of the most frequent varieties of these crystals are shown in fig. 49. I have now met with many cases in which these various crystals have been present. Some of these have been under my care for months; and I have had repeated opportunities of examining the urine. The remarkable crystals now referred to, became in all mixed with, and ultimately replaced by, the ordinary octohedral variety.

220. These dumb-bells and oval crystals, although I have always described them as oxalate of lime, have always presented a very serious difficulty to their being thus regarded, in consequence of the peculiarity of their

dumb-bell formation, of which Fig. 50, taken from his paper in the twenty-third number of the 'British and Foreign Medico-Chirurgical Review,' offers

Fig. 50.

a fair illustration. He remarks that soluble dumb-bells in the urine frequently consist of sulphuric acid in combination with soda or potash.

optical characters. It is well known that all crystals referable to the cube or regular octohedron never possess double refraction, and hence scarcely exert any influence upon a plain polarized ray of light. In accordance with this law, the ordinary crystals of oxalate of lime do not in the slightest degree exhibit the phenomena of colour when examined in the polarizing microscope; merely in the slightest degree, if lying in a favorable position, appearing illuminated, when the polarizing prisms are crossed. On the other hand, the dumb-bell crystals, as I long ago stated, exhibit a beautiful series of coloured rings traversed by a black cross. Recently I had an opportunity of carefully examining the chemical re-action of these crystals. A gentleman* who had been under the care of the late Dr. Prout, consulted me shortly after his lamented death, and on drawing my attention to his urine, I observed the most copious deposit of the crystals in question I ever witnessed. Without much difficulty I obtained a sufficient quantity for the following experiments:

A. They slowly dissolved in boiling dilute hydrochloric acid, from this solution ammonia threw down a white precipitate. The whole was left in a watch-glass to spontaneous evaporation. Very large and fine *cubes* of hydrochlorate of ammonia, unmixed with any of the ordinary phomose crystals were left. Mixed with these was a white amorphous powder of oxalate of lime.

* This gentleman, whom I have frequently seen, has told me that, at the time when these crystals were observed, he had, by Dr. Prout's direction, been living mainly on meat, taking it thrice a day; he had also been using the doctor's acid mixture.

B. Kept under water in a warm greenhouse for ten days, the mixture evolved a fœtid ammoniacal odour, and some of the dumb-bells had become replaced by ordinary octohedral crystals of oxalate of lime.

C. Boiled in strong hydrochloric acid, they readily dissolved, and were totally changed. For on spontaneous evaporation a series of tufts of beautiful crystalline needles were left exactly like oxalate of ammonia; but differed from it in being totally insoluble in water and readily soluble in a drop of hydrochloric acid.

D. Boiled in strong nitric acid they readily dissolved without change, for a drop of the solution allowed to evaporate spontaneously on a plate of glass, left a crystallized mass of dumb-bells, generally more elegant and regularly crystallized than they are met with in the urine. Hastily evaporated, the crystals became nearly circular.

E. Ignited in a platinum spoon they blackened, evolved an odour of burnt horn, and readily became white without appearing to diminish in bulk. Under the microscope, the crystals appeared to be unaffected in shape, but were opaque. They reddened moistened turmeric paper, were insoluble in water, and dissolved in dilute sulphuric acid with violent effervescence, leaving, by evaporation, crystals of sulphate of lime.

221. I was unable to proceed further in these investigations, for the deposit, on the patient's marriage, became suddenly replaced by the ordinary octohedral

crystals, and I could not procure any more of the dumb-bell form.* We may, however, safely conclude that they do not consist of mere oxalate of lime, for their powerful action on polarized light is quite incompatible with their being composed exclusively of this salt. The action of heat (E) shows that they are readily converted into carbonate of lime without change of form. The experiment with hydrochloric acid and ammonia (c) would seem to render it probable that urea was in some way evolved as the resulting hydrochlorate crystallized in cubes. The different influence of nitric and hydrochloric acid is exceedingly interesting, and merits a careful study whenever an opportunity presents itself for their investigation. Most microscopic observers are familiar with the optical properties of oxalurate of ammonia, and coupling the complete resemblance of crystalline form and double refracting power of this salt with the dumb-bell deposits, I think we may venture to assume the high probability of the latter consisting of oxalurate of lime, a salt which differs from oxalate of lime in ultimate constitution only in the presence of the elements of urea and absence of the constituents of water; for

		C N H O
2 atoms	oxalic acid	4 6
1 „	urea	2+2+4+2
		6+2+4+8
−1 „	water	1+1
= „	oxaluric acid	6+2+3+7

* Although I have examined several specimens of this gentleman's urine, I have never since recognised the dumb-bell crystals. The octohedral ones, however, are present in great numbers and various sizes on the recurrence of a common catarrh or attack of dyspepsia.

222. Dr. Frick, of Baltimore,[154] has stated that the dumb-bell crystals do not contain lime, and that they consist of uric acid. This extraordinary assertion was not founded on any analysis of the crystals I have described, and rests on no better foundation than that uric acid, when kept under water for some time, as well as when precipitated under certain circumstances, present an approach to the dumb-bell form.* It has been long known that uric acid will sometimes assume the form of plates excavated at the sides (122), but really remaining so utterly unlike the crystals I described, that it is difficult to conceive any one committing so remarkable an error. For crystals which dissolve in boiling nitric acid without change, and at a red heat are converted into carbonate of lime, can hardly be mistaken for uric acid.

223. Dr. Bacon,[153] another American physician, in a most elaborate paper, displaying great power of research, read before the Boston Society for Medical Observations, has completely refuted Dr. Frick's hypothesis, and has added very largely to our knowledge of the chemistry of the dumb-bell crystals. Dr. Bacon is inclined to believe that the oval crystals I have described are dumb-bells seen end-wise, they show, with polarized light, one or two circular coloured rings near the centre, and an oval band near the outside. On submitting the crystals to heat and the action of acids, he obtained the same results as myself. He, however, ascertained that strong acetic acid (containing 39 per cent. of glacial acid) slowly dissolved them, forming a transparent solution, which, on spontaneous evaporation, left an abundance of zeolitic crystals, varying in figure from circular striated plates to

* Vide fig. 28 *a*, where true dumb bells of uric acid are represented.

dumb-bells. Mixed with these are a few long four-sided prisms, which exhibited, like the zeolitic crystals, beautiful coloured bands, when examined with polarized light.

224. When digested in a cold solution of carbonate of soda, Dr. Bacon found that the dumb-bells became opaque and were disintegrated, a white deposit of carbonate of lime in a few hours formed at the bottom of the vessel. This dissolved with effervescence in acetic acid, and the solution was rendered opaque on the addition of oxalate of ammonia. The fluid decanted from the carbonate of lime of course contained a soda salt, of the acid of the dumb-bell. On neutralizing this with nitric acid, the solution gave a precipitate with nitrate of silver, soluble in nitric acid as well as in ammonia. The silver precipitate did not fulminate with heat like oxalate of silver.

225. Dr. Bacon examined the effect of the different acids on artificially prepared oxalate of lime. He ascertained that when dissolved in hydrochloric acid, an abundance of zeolitic forms were obtained by hasty evaporation. But when allowed to evaporate spontaneously, a mixture of transparent rhomboidal plates, minute octohedra and four-sided prisms often arranged in rosettes, with the zeolitic crystals, were obtained. The rhomboids and zeolite groups acted powerfully on polarized light, the prisms less strongly, and the octohedra not at all. On submitting these crystals to analysis, the rhomboids were found to contain hydrochloric acid, but the prisms and octohedra were pure oxalate of lime. Oxalate of lime slowly dissolved in very strong acetic acid, and, on rapidly evaporating the solution, circular radiated crystals were left; they were frequently

fissured in one or two places, and exhibit the cross and rings by polarized light.

Dr. Griffith had previously ascertained that artificial oxalate of lime, dissolved in nitric acid and evaporated, left a deposit of radiated crystals very like the dumb-bell crystals.

From the results of all his experiments, Dr. Bacon expresses his opinion that the dumb-bell crystals I have described consists of a "salt of lime containing either oxalic, oxaluric, or, perhaps, some other organic acid easily converted into oxalic acid; but the exact nature of the acid remains to be determined by future investigation."

226. The greatest possible variation in the size of these crystals is often observed, not only in different specimens of urine, but often in the very same portion. I have often met with small octohedra of oxalate mixed with others four or six times larger in a single drop of urine. The following measurements were made from some specimens preserved between plates of glass; by means of the beautiful micrometer of Powell, belonging to the large microscope constructed by him for Guy's Hospital:

	Inch.
Length of a side of the largest octohedra . .	$\frac{1}{750}$
" " smaller ditto . . .	$\frac{1}{3750}$
" " smallest ditto . . .	$\frac{1}{5600}$
" " octohedra in the urine of a horse .	$\frac{1}{150}$
Long diameter of large "dumb-bell" crystals . .	$\frac{1}{583}$
Short diameter of ditto	$\frac{1}{750}$
Diameter of some nearly circular . . .	$\frac{1}{500}$
Long diameter of the smallest "dumb bells" . .	$\frac{1}{7118}$
Short diameter of ditto	$\frac{1}{9500}$

Characters of urine containing the Oxalate and Oxalurate (?) of Lime.

227. In the great majority of cases the urine is of a fine amber hue, often darker than in health, but never presenting to my view any approach to the greenish tint which has been described as characteristic of this secretion during the presence of the oxalic diathesis, unless the colouring matter of blood be present. In a few cases the urine was paler than natural; and then was always of lower specific gravity. This, however, was in most instances but a transient alteration, depending upon accidental causes; the odour was generally natural, rarely aromatic like mignionette. In many instances a deposit of urates, occasionally tinted pink by purpurine, fell during cooling. I have observed this to be infinitely more frequent during the spring than summer: hence it in all probability depended upon the influence of cold upon the cutaneous functions, causing a large amount of nitrogen and carbon, under the form of urates and purpurine, to be excreted by the kidney (138). The specific gravity of oxalic urine varies extremely; in rather more than half the specimens being, however, between 1·015 and 1·025. In eighty-five different specimens of which I preserved notes, the ratio of the densities was as follows:

In 9 specimens	the specific gravity	ranged from	. 1·000 : 1·015
In 27	„	„	. 1·016 : 1·020
In 23	„	„	. 1·021 : 1·025
In 26	„	„	. 1·025 : 1·030

The densities of the specimens of urine passed before going to bed at night, and immediately on rising in the

morning, were frequently very different; thus, in twenty-six cases in which the night and morning urine were separately examined:

The night specimen was heaviest in . . .	12
The morning specimen heaviest in . . .	5
Both alike in	9

And, as a general rule, the heaviest specimens contained most of the oxalate. It seldom happened that the total quantity of urine passed in these cases very much exceeded the average proportion; in a very few only, positive diuresis could be said to exist. Frequently the patients have, from occasional irritability of bladder, mistaken the frequent desire to pass urine for an increased quantity; but the absence of any very considerable increase was proved by positive measurement of the quantity of urine passed in twenty-four hours.

228. Some of the specimens of oxalic urine gave a precipitate with salts of lime, insoluble in acetic acid, and consisting of oxalate of lime. This, in some instances at least, depended on the presence of oxalate of ammonia, or of some other soluble salt of this acid.

The acidity of these specimens was always well marked, often far more so than in health, and never being absent. I have not yet met with a single case in which an alkaline, or even positive neutral, state existed, unless complicated with calculus or diseased bladder.

A greater increase in the quantity of urea, than the density of the urine would have led us to suspect, was frequently found; indeed, I have scarcely met with a specimen in which, when the density was above 1·015, distinct indications of an excess of urea were not met

with. In twenty-four of the eighty-five specimens above referred to, so large a quantity was present, that very rapid, and in some almost immediate, crystallization ensued on the addition of nitric acid. In general, in cases where the greatest excess of urea was present, the largest and most abundant crystals of the oxalate were detected.

Mr. J. H. Stallard, of Leicester, who has contributed some important information on this subject, has discovered that in oxalic urine the indeterminate organic matters (57) are greatly increased, often reaching nearly double the average proportion excreted in twenty-four hours. I can fully confirm the accuracy of this observation, and indeed believe that it explains the emaciation so frequent in this affection. Dr. Maclagan* has observed, on this subject, that the mean density of the urine was 1024·4; that the observed difference of density between the morning and evening urine was confirmed, and had reference to the fact that the presence of oxalate in the urine was commonly connected with a disorder, more or less important, of the digestive and assimilative processes; that the colour was paler than that of healthy urine; that the sweet-briar odour was frequently present; that in some instances the urine was more or less fetid, but never ammoniacal, and but seldom even resinous; that the reaction was in general strongly acid.

* 'Edinburgh Monthly Journal,' Dec. 1853 and Jan. 1854.

Complication of the Oxalate of Lime with other deposits.

229. In more than half the cases, the oxalate of lime was found unmixed with any other saline deposit; in a very few, crystals of uric acid were found from the first, mixed with the octohedra of oxalate of lime; and in nearly all the successful cases, this acid appeared in the course of the treatment, and ultimately replaced the oxalate altogether, at a period generally contemporary with the convalescence of that patient. Much more rarely, prisms and stellæ of the ammoniaco-magnesian phosphate were found mixed with the oxalate, and occasionally replacing it in the course of the treatment; and still less frequently the phosphate was observed in the urine some time before the appearance of the oxalate.

In several specimens a copious troubling was produced on the application of heat; this generally depended upon the precipitation of the earthy phosphates, as a drop of dilute acid immediately restored the limpidity of the fluid. This troubling, in very few cases, has been found to depend upon the presence of albumen, and then it was usually transient, and generally traceable to the presence of some secretions from an irritable vesical mucous membrane. I have met with but few well-marked instances of a complication of this oxalic affection with granular degeneration of the kidneys.

Out of the eighty-five cases before referred to (227),

Oxalate was present unmixed in	43 cases.
Mixed with urates	15
Mixed with uric acid	15
Mixed with triple phosphate	4
Phosphate deposited by heat	8
	85

In one of the specimens containing the triple phosphate, the application of heat produced a deposit of the earthy salts.*

230. Much oxalate of lime often crystallizes from urine after sufficient repose, and even if, in cases of oxaluria, the fresh urine be filtered through paper so as to separate every trace of deposit, and then set aside for twenty-four hours, a fresh formation of crystals will be detected.

One very constant phenomenon is observed in the microscopic examination of oxalic urine, viz., the presence of a very large quantity of epithelial cells (341); it is, indeed, the exception to the general rule to meet

	Morning Urine.	*Evening Urine.*
* Dr. Maclagan found that the oxalates were unmixed in	16	14
" " with other saline deposits	16	20
" " not examined	5	3
	37	

Of the saline constituents the urates alone occurred frequently; next in order but comparatively rarely were found uric acid, oxalurates, and amorphous phosphates; and then, in almost solitary instances, triple phosphate, cystine, xanthine, pus, sugar, blood, and in six instances a more or less marked reaction of purpurine. The epithelium in 37 specimens

	Morning Urine.	*Evening Urine.*
was copious	12	10
" trifling	20	24
" not examined	5	3
	37	

As a general rule the oxalate was more abundant in the evening than in the morning urine.

with this form of urine free from such an admixture. So constantly has it been found, that a white deposit of epithelium has repeatedly attracted my attention, and led to the suspicion of the probable presence of oxalate of lime. Sometimes the cells of epithelium are found unaltered in form, being more or less oval and distended with fluid, more frequently they are empty, and then resemble flat oval scales, marked with a circular spot in the centre. Sometimes irregular lacerated fragments of epithelial structure are met with; and frequently, if the light is not too intense, a portion of the urine can, under the microscope, be seen to be full of them.

231. Although the oxalate of lime is generally found diffused through the urine, yet, if much mucus is present, so as to form a tolerably dense cloud, the salt may often be seen entangled in its meshes like glistening points; and whenever any other matter is present, which becomes deposited by repose, a greater portion of the oxalate will almost invariably fall with it. This is particularly the case when triple phosphate of magnesia and ammonia, or uric acid, exists under the form of a crystalline deposit; for on submitting a portion of this to the microscope, the octohedra of oxalate may be readily detected mixed with the prisms or stellæ of the former, or with the tables or lozenges of the latter.

Pathological origin of Oxalate of Lime.

232. This question is one of great interest, and becomes the more important since the discovery of the very frequent existence of this salt in the urine; so that, instead of being very rare, it really is considerably more frequent than many other deposits (213). It is

scarcely possible to avoid being impressed with the very probable physiological relation between oxalic acid and sugar: we know that the latter substance forms a considerable item in our list of aliments; we know that the great majority of farinaceous matters are partially converted into this element during the act of digestion.[86] It is indisputable that, under certain circumstances, it finds its way into the blood, and is eliminated by the kidneys; even when artificially introduced it is thus thrown out of the system. I have in my possession fine crystals of sugar, prepared by Dr. Percy from the urine of a dog, into whose veins he had previously injected a solution of that substance. Lastly, we know that, under certain morbid influences, the great proportion of our food may, whilst in the stomach, be converted into sugar, which, becoming absorbed, rapidly passes through the circulation, and is thrown out of the system by the kidneys as an effete matter, with the effect of producing more or less rapid emaciation, and in most cases leading to fatal marasmus. Dr. Aldridge,[141] of Dublin, has even suggested the probability of a substance analogous to sugar, capable of undergoing acetous fermentation, being a normal element of the urine. Then, recollecting the facility with which sugar and its chemical allies, as starch, gum, and wood fibre are, under the influence of oxydizing agents, converted into oxalic acid, and having sufficient amount of evidence to prove that when oxalic acid is really found in the urine, symptoms bearing no distant relation to those of a diabetic character are met with, we are almost inevitably led to draw the induction that the oxalate of lime found in the secretion owes its origin to sugar, and to locate the *fons et origo mali* in the digestive organs. It was only after extended observation that I convinced myself that the connection

between oxalate of lime and sugar is by no means a necessary one (234).

233. That some very slight disturbing causes influencing the assimilative functions will give rise to the presence of oxalate in the urine is perfectly true, even when the food taken does not contain oxalic acid ready formed, but this is generally a temporary change, and soon disappears on the removal of the exciting cause. Far different are the results and character of those cases in which a deposit of oxalate steadily continues for some time. A disease of great consequence, of often serious importance, is then set up, one which demands very great attention on the part of the physician.

From a careful examination of the urine in a large number of these cases, I have arrived at the following conclusions regarding the circumstances under which oxalate of lime occurs in the urine.

1. That in the urine under examination oxalate of lime is present partly dissolved in, and partly diffused through the fluid, from whence it is deposited in a crystalline form.

2. That in rather more than one third of the cases uric acid or urates existed in large excess, forming the greater bulk of the existing deposit.

3. That in all, there exists a greater proportion of urea than in natural and healthy urine of the same density; and in nearly 30 per cent. of the cases, so large a quantity of urea was present, that the fluid crystallized into a solid mass on the addition of nitric acid.

4. That the urates found in the deposits of oxalic urine is occasionally tinted of a pink hue.

5. That an excess of phosphate frequently accompanies the oxalate.

6. That the existence of sugar in the specimens I have examined is the exception to the rule.

234. Every one is now familiar with the composition of the urine in diabetes, and it has been determined, from extended observation, that, as a general rule, diabetic urine very seldom contains in a given quantity any excess of urea, uric acid, or urates, especially the pink variety; and that this secretion is remarkably free from saline deposits; the increased specific gravity depending upon the presence of large proportions of sugar. In the oxalic urine under consideration, the density *increases with the quantity of urea*, which is often present in large excess. Indeed I regard the presence of a greater or a less excess of urea almost as characteristic of the morbid state of urine for which I am contending as the oxalate of lime itself. Deposits of uric acid and urates are also frequent; and, further, no analogy whatever with saccharine urine exists, save in density, which we have already learned depends upon a totally different cause. Thus, so far as the abstract examination of the urine is concerned, not the slightest countenance is given to the idea of there being any relation between oxalic and saccharine urine, however much our preconceived and hypothetical views may have led us to expect the existence of such. In but few instances have I yet found sugar present in oxalic urine; and although these investigations were commenced with a strong bias in favour of the almost necessary connexion between the presence of saccharine matter and oxalic acid, yet, in proportion as I have extended my researches, this idea became less and less supported by experience. In fact, I have very rarely met with oxalate of lime in diabetic urine. What, then, is the source of the oxalate of lime? and how can its continued production be explained con-

sistently with the phenomena presented by the urine? From the symptoms presented in cases of this disease, there is no difficulty in proving to a demonstration the positive and constant existence of serious functional derangement of the digestive organs, especially the stomach, duodenum, and liver; and, further, that the quantity of oxalic acid generated is, to a very considerable extent, under the control of diet; some articles of food quite free from oxalic acid at once causing the excretion of this substance in very large quantities, whilst others appear to have the effect of nearly totally checking it. These circumstances alone, together with the emaciation so generally present in the disease under consideration, at once prove, that whatever be the immediate agent which causes the kidneys to secrete the oxalic acid from the blood, the primary cause must, as Dr. Prout has well and satisfactorily shown, be referred to an unhealthy condition of the digestive and assimilative functions.

235. That the oxalic acid really does find its way into the blood, has been proved beyond all doubt by Dr. Garrod. This gentleman, who so successfully demonstrated the presence of urate of soda in the circulating fluid, was kind enough to place in my hands some octohedral crystals he obtained from the serum of blood of a patient labouring under albuminuria. From all the observations I was able to make on these crystals, I can fully confirm the accuracy of Dr. Garrod's opinion of their consisting of oxalate of lime. They were obtained in the following manner. The serum of blood was evaporated to dryness and digested in alcohol, the insoluble residue was treated with boiling water, evaporated and mixed with acetic acid with the view of detecting uric acid. Instead of crystals of this substance a white deposit of octohedral oxalate of lime fell. It is difficult to

explain the presence of so insoluble a salt in solution in the blood, but it is very probable that the opinion of Dr. Schmidt[156] of Dorpat may be correct. He has assumed that there exists in the animal economy a tendency to the formation of a soluble triple compound of oxalic acid, lime, and albumen (oxalsaures albumin-kalk,) which, by its decomposition, allows oxalate of lime to crystallize. Probably such a compound exists in the blood in disease, and when the acetic acid is added, as in Dr. Garrod's process, the albumen is separated, and the oxalate set free. A compound of this sort exists in yeast-cells, for when recent, minute microscopic examination fails to detect any crystals, but when kept long enough to undergo decomposition, octohedral crystals of oxalate were found by Dr. Schmidt to be abundantly evolved. Very recently Mr. Simons has given an account of a membranous cyst which he found on the olfactory nerve of a horse, containing a large crystal of oxalate of lime.[157]

236. As an excess of urea, and often of uric acid, in most instances co-exists with deposits of oxalate of lime, it is highly probable that both these unnatural states of the secretion are produced by the same morbid influence. Further, when the very remarkable chemical relation existing between uric acid, urea, and oxalic acid, is borne in mind, as well as the readiness with which the former of these bodies is convertible into the latter, is it not legitimate to suppose that the disease under consideration may be regarded as a form of what has been aptly termed by Dr. Willis azoturia (of which an excess of urea is the prevalent indication,) in which the vital chemistry of the kidney has converted part of the urea, or of the elements which would in health have formed this substance into oxalic acid? This view appears to me to be supported

by what I have observed of the history, symptoms, and progress of the cases, as contrasted with the changes presented by the urine during treatment. It may, however, be asked, from whence are the nitrogenized matters derived, whose metamorphic changes (31) give rise to the formation of oxalic acid? are they derived from the tissues of the body, like healthy urea and uric acid (38)? Of course it is quite possible that such may be their origin, but as the quantity of oxalate of lime deposited from the urine is always the greatest after a full meal, and often absent in the *urina sanguinis*, or that passed on rising in the morning, frequently disappearing under the influence of a carefully regulated diet, and re-appearing on returning to the use of unwholesome food, it is highly probable that this salt is, in the majority of cases, primarily derived from the mal-assimilated elements of food, and not, like uric acid generally, a product of metamorphosed structures.*

237. The ready conversion of uric into oxalic acid, under the influence of oxydizing agents, has been satisfactorily demonstrated by Professors Liebig and Wohler; for when uric acid is heated with water and peroxide of lead, the latter gives up part of its oxygen, and oxalic acid, with allantoin, the peculiar ingredient of the allantoic fluid of the fœtal calf, are generated. The ultimate constitution of this substance differs from that of oxalate

* I am inclined to the opinion, though not as yet furnished with sufficient facts to assert it confidently, that whenever the crystals of oxalate of lime are not to be found in the morning urine, *i. e.* in the *urina sanguinis*, the case is more one of ordinary dyspepsia, the deposit being the result of changes in the nitrogenized food, and may generally be relieved by the usual treatment; but that if not so relieved, it passes on to the stage of confirmed oxaluria,—when the deposit is due to the abnormal destructive assimilation of effete tissues,—Liebig's metamorphosis of tissue.

of ammonia only in the absence of the elements of water. In the following equation this decomposition of the allantoin is assumed to have occurred—

	C	N	H	O		C	N	H	O	
1 atom uric acid =	10 +	4 +	4 +	6	=	2 +	2 +	4 +	2 =	1 atom urea.
+ 2 „ oxygen =				2		4			6 =	2 „ oxalic acid.
+ 6 „ water =			6 +	6		4 +	2 +	6 +	6 =	2 „ oxalate of ammonia.
	10 +	4 +	10 +	14		10 +	4 +	10 +	14	

The readiness with which, under certain circumstances, uric acid is converted into the oxalate, may be well illustrated by a fact which has been observed in connexion with the *guano* of South America (87), a substance now so largely employed as a manure. This contains, when recent, a considerable proportion of urate of ammonia, which salt, after a certain length of time, often during the voyage to this country, nearly wholly disappears, and is replaced by oxalate of ammonia. The urinary excretion of caterpillars, consisting chiefly of urate of ammonia, is also frequently found to contain fine crystals of oxalate of lime. The theoretical relation between urea and oxalic acid is readily shown; for if we conceive urea to exist in the blood, and it be the duty of the kidney to separate it, we have only to assume that its elements undergo a re-arrangement in the act of elimination from the circulating mass, the result of which is the appropriation of the elements of water and evolution of oxygen, to ensure the conversion of urea into oxalate of ammonia, We know that under a depressing influence exerted on the nervous system at large, or upon a portion of it connected with the functions of the kidney, as during typhus adynamic fever on the one hand (271), and blows over,

or a fracture of the spine on the other (274,) such decomposing influence is unquestionable, and the urine becomes loaded with carbonate of ammonia from a re-arrangement of the component elements of the urea; one atom of urea and two of water being resolved into two atoms of carbonate of ammonia. If, then, this depressing influence be modified so as to interfere with the formation of an alkaline salt, we may suppose it probable that urea may undergo a different metamorphosis, and become converted into oxalic acid, ammonia, and oxygen.

$$\left.\begin{array}{lr} & \text{N H O} \\ \text{1 atom urea} & =2+2+4+2 \\ & \\ \text{2 ,, water} & = \quad 2+2 \\ \hline & 2+2+6+4 \end{array}\right\} = \left\{\begin{array}{ll} \text{C N H O} & \\ 2 \qquad\quad 3 & = \text{1 atom oxalic acid.} \\ \quad 2+6 & = \text{2 ,, ammonia.} \\ \qquad\qquad 1 & = \text{1 ,, oxygen.} \\ \hline 2+2+6+4 & \end{array}\right.$$

238. Since the first publication of this formula, Professor Liebig has suggested that oxalic acid is a derivative of uric acid and not of urea, thus :—

$$\left.\begin{array}{lr} & \text{C N H O} \\ \text{1 atom of uric acid} & = 10+4+4+6 \\ \text{4 ,, water} & = \quad 4+4 \\ \text{3 ,, oxygen} & = \qquad 3 \\ \hline & 10+4+8+13 \end{array}\right\} = \left\{\begin{array}{ll} \text{C N H O} & \\ 4+4+8+4 & = \text{2 atoms urea.} \\ & \\ 6 \qquad\quad 9 & = \text{3 ,, oxalic acid.} \\ \hline 10+4+8+13 & \end{array}\right.$$

It is, however, a matter of very secondary importance whether the oxalic acid be a derivative of uric acid or urea, considering the close relation which exists between these two bodies (82). From whatever source it may arise, the presence of oxalic acid in the urine must necessarily lead to the formation of oxalate of lime, as this acid readily precipitates lime from all its combinations with acids.

239. Having traced the origin of oxalate of lime deposits to changes in nitrogenized food, or to an abnormal destructive assimilation of effete tissues, it becomes next of importance to direct attention to the fact that this salt may often be a direct derivative from vegetable food, for it is quite certain, from the researches of Schleiden and others, that oxalic acid is of all acids that which is most extensively diffused through the vegetable kingdom. In the polygonaceæ, it particularly abounds, and after the ingestion of preparations of rhubarb and sorrel, crystals of oxalate of lime can always be detected in the urine. Oxalate of lime constitutes a large proportion of the acicular crystals or raphides so common in the intercellular lacunæ of many plants, and in the liber of trees it is of very frequent occurrence. These crystals of oxalate of lime are developed in the cells of the vegetable structure, and it is impossible to avoid being struck with the curious analogy presented in the formations of cells in both animal and vegetable life. In fig. 51, at *a*, *b*, are shown cells from the outer layer of the bulb of an onion, containing crystals of oxalate of lime in octohedra and prisms, figured by Mr. Quekett, and at *c* is an epithelial cell filled with octohedral crystals of the same salt which was detected in the urine by Dr. G. Johnson. The physiological origin of oxalic acid in vegetables is referable to a process of de-oxydation, and admits of ready explanation. It is well known that under the influence of light the leaves of plants possess the power

Fig. 51.

of decomposing the carbonic acid of the air, and evolving its oxygen, the carbon becomes fixed in their tissue. The generation of oxalic acid becomes a nearly necessary result of the first stage of this deoxygenizing action, and most of the other vegetable acids may be regarded as the results of ulterior changes. Thus:

$$
\begin{array}{lrrrl}
 & C & H & O & \\
 & 12 + & & 24 & = 12 \text{ atoms of carbonic acid.} \\
- & & & 6 & \\
\hline
 & 12 + & & 18 & = 6 \text{ atoms of anhydrous oxalic acid.} \\
+ & & 6 + & 6 & = 6 \text{ atoms of water.} \\
\hline
 & 12 + & 6 + & 24 & = 6 \text{ atoms of hydrated oxalic acid.} \\
- & & & 9 & \\
\hline
 & 12 + & 6 + & 15 & = 1\tfrac{1}{2} \text{ atom of tartaric acid.} \\
- & & & 3 & \\
\hline
 & 12 + & 6 + & 12 & = 1\tfrac{1}{2} \text{ atom of malic acid.} \\
- & & 1 + & 1 & = 1 \text{ atom of water.} \\
\hline
 & 12 + & 5 + & 11 & = 1 \text{ atom of citric acid.} \\
- & & 2 + & 2 & = 2 \text{ atoms of water.} \\
\hline
 & 12 + & 3 + & 9 & = \text{lichenic acid, \&c.}
\end{array}
$$

Thus we are authorised in assuming that animals and vegetables generate oxalic acid by two very distinct processes, the former by oxydation, the latter by de-oxydation.

These facts show the vast importance of carefully ascertaining the peculiarities of the patient's diet before giving too confident an opinion as to the morbid state of the urine.

240. The use of rhubarb and sorrel is, as I have already stated, a common source of oxalate of lime in the urine. Tomatoes also contain enough of a soluble salt of oxalic acid to cause a deposition of oxalate of lime in

the urine. The abundance of the oxalate of lime which I have shown to exist in the urine of the horse is probably owing to the quantity of sorrel always present in hay. Some careful researches into the influence of food in causing the appearance of oxalate of lime in the urine have been made by Mr. Rose of Swaffham. He has shown that many articles of ordinary diet are sufficient to produce a temporary oxaluria, under certain states of health; turnips and onions have thus appeared to determine its presence. It seems that oxalate of lime taken into the stomach does not, on account of its insolubility, enter the blood, nor reach the urine. In good states of health, onions, although containing an abundance of crystallized oxalate of lime, do not generally cause this substance to appear in urine.

241. It hence becomes a very important matter to diagnose between deposits of oxalate of lime which acquire their acid directly from the food in which it existed ready formed, and those in which its origin is strictly pathological. The nature of the patient's food will soon enable us to resolve this question satisfactorily. It may, however, often assist in our diagnosis to recollect that the great acidity, the high specific gravity, and excess of urea generally present in true oxaluria, will often at once distinguish between a deposit the result of diseased action and one of accidental origin.

242. It is a curious circumstance, that oxalate of lime exists in many mucous secretions, and may hence be occasionally found on the surface of mucous structures in a crystallized form. In this state it has been detected in the mucous membrane of the gall-bladder and of the uterus during pregnancy.

Symptoms accompanying the secretion of Oxalic Acid.

A. Oxaluria, with excess of urea and extractive matter in the urine.

243. It is impossible to connect any definite set of symptoms with *all* cases in which the oxalate of lime appears in the urine, indeed persons will often go about their ordinary duties in apparently fair health for a long time, and yet be constantly excreting the oxalate of lime. In consequence of this, some persons have actually affirmed that oxalate of lime has no relation with any pathological state of the system, and its appearance in the urine is of no consequence. This opinion can result from very limited experience alone; indeed I am not sure that Lehmann, valuable as is his opinion as a chemist, has any claim on our confidence as a practical physician; and he is chiefly referred to as advocating the erroneous view I have alluded to. If this kind of reasoning be admitted, the existence of albumen or blood in the urine might be regarded as of no importance, because we often meet with patients affected with this very condition, and yet are so free from apparent indisposition, that we are often unable to persuade them to take care of their health, until the disease indicated by the state of urine in question has proceeded to an incurable condition.

244. Persons affected with the form of disease referable to this class are generally remarkably depressed in spirits, and their melancholy aspect has often enabled me to suspect the presence of oxalic acid in the urine. Sometimes a peculiar lurid greenish hue of the surface

has been observed, but more generally the face has the dark and dingy aspect so common in some forms of dyspepsia in which the functions of the liver are deranged. They are generally much emaciated, excepting in slight cases, extremely nervous, and painfully susceptible to external impressions, often hypochondriacal to an extreme degree, and in very many cases labour under the impression that they are about to fall victims to consumption. They complain bitterly of incapability of exerting themselves, the slightest exertion bringing on fatigue. Some feverish excitement, with the palms of the hands and soles of the feet dry and parched, especially in the evening, is often present in severe cases. In temper they are irritable and excitable; in men the sexual power is generally deficient, and often absent, an effect probably owing to the exhaustion produced by the excessive secretion of urea so common in this affection (220). A severe and constant pain, or sense of weight across the loins, is generally a prominent symptom, with often some amount of irritability of bladder. The mental faculties are generally but slightly affected, loss of memory being sometimes more or less present. Well-marked dyspeptic feelings are always complained of. Indeed, in most of the cases in which I have been consulted, I have been generally told that the patient was ailing, losing flesh, health, and spirits, daily; or remaining persistently ill and weak without any definite or demonstrable cause. The urine is always of high specific gravity, often being within the diabetic range, and seldom below 1·025 or 1·030. This increase of specific gravity depends not only upon an excess of urea (for the urine generally crystallizes readily with nitric acid), but upon the existence of an abnormally large proportion of the extractive matters of the secretion (54).

It is invariably acid, often excessively so. The tendency to eruptions of minute furunculi, and even sometimes of large boils, is an exceedingly frequent concomitant of the state of urine under consideration, and becomes a striking indication of the depressed state of the general health. In some instances the patients have been suspected to be phthisical. It is, however, remarkable, that I have yet met with very few cases in which phthisis was present. In very few instances only have I seen the cases terminate in the formation of a calculus. As to the source of the oxalate of lime, it can, I think, only be referred to the same origin as the accompanying urea (237) and extractive matters, viz., an exaggerated activity of the second stage of the secondary or destructive assimilation, the metamorphosis of tissue of Liebig. It is only in this way that the attending emaciation can be satisfactorily accounted for.

B. Oxaluria, unattended by excess of urea or extractive matter.

245. In these cases the oxalate of lime is generally merely one of a series of symptoms developed under the influence of diseases which interfere with the assimilative functions; perhaps of those which affect most prominently the integrity of function of the ganglionic nerves. Hence, in many acute diseases, a deposit of oxalate of lime is not uncommon, especially in acute rheumatism. The deposits of urates so frequent in this painful disease being rarely free from the crystals of the oxalate.

When it thus occurs, it is not to be regarded as involving the necessity of special treatment, and gene-

rally disappears *pari passu* with the cure of the accompanying malady.

246. Among chronic diseases (especially in certain forms of chronic dyspepsia), attended by gastralgia, oxalate of lime often abounds in the urine, and seems to act as a local irritant. This is exceedingly frequent among persons whose nervous systems become much excited by anxiety, and the pressure of important business. It has occurred to me repeatedly to notice this state of things in barristers and solicitors, especially when hard worked. The irritability of bladder, so common an ailment among many members of the legal profession, has been, in so many cases which have fallen under my notice, accompanied by the abundant excretion of crystals of oxalate of lime, and has disappeared on the removal of this deposit, that I cannot avoid regarding this substance as playing the part of a local irritant.*

247. In some chronic affections of the air-passages, oxalate of lime has been abundantly met with in the urine, and perhaps more frequently in old bronchitis with emphysematous lungs than in other affections. Lehmann has offered an ingenious explanation of this, by supposing that in the deficient state of the pulmonary functions, oxygenation of carbon is partly performed vicariously in the capillary structure of the kidneys, oxalic acid ($C_2\,O_3$) being formed instead of carbonic acid ($C\,O_2$).

248. The immediate exciting causes of the secretion of oxalic acid are, in the majority of cases at least, generally well marked; and in nearly all the predisposing

* I have observed, in several cases, a burning sensation over the iliac region, and the parts supplied by the superficial branches of the first division of the lumbar plexus.

cause is the same, viz., a chronic and persistent derangement of the general health, or the result of previous acute disease, dyspepsia, injury to the constitution by syphilis and mercury (Case I), by childbearing and over-lactation, by venereal excesses or intemperance (Cases III, VII). The accession of the disease has generally been traced to some circumstance which has determined the irritation to the urinary organs. Among the most frequent of these causes, I have observed exposure of the lower part of the spine to cold (Case II), mechanical violence inflicted over the kidneys (Case VI), severe irritation following the introduction of a bougie or catheter, or unnatural excitement of the genital organs, as shown by the frequent occurrence of involuntary seminal emissions (Case V). The most inveterate case of this kind I have ever met with was in the person of a gentleman, who committed the worse than foolish act of testing his sexual powers, previous to his marriage, by sleeping with two women. The result was an epileptic fit, and for three years after he paid a heavy penalty for his folly in the persistence of the symptoms above described in an aggravated form, so that he dragged on a miserable existence, although surrounded with everything which ought to render life happy.

Dr. Rigby has lately shown that deposits of oxalate of lime occur often during the existence of functional and organic disease of the uterus. In many cases, however, no other obvious cause existed than great mental anxiety (Case IV), produced by excessive devotion to business or study.

Therapeutical indications.

249. The treatment, in the majority of cases, is very successful; a few only resisting all the plans which were

adopted. As a general rule the functions of the body, where obviously imperfect, should be corrected, the general health attended to by the removal of all unnaturally exciting or depressing influences, the skin should be protected from the sudden alternations of temperature by a flannel or woollen covering, and the diet carefully regulated. This has generally consisted of well-cooked digestible food, obtained in about equal proportions from the animal and vegetable kingdom; all things which tend to produce flatulence being carefully avoided. The drink should consist of water, or some bland fluid, beer and wine being generally excluded, especially the former, unless the patient's depression render such positively necessary. A very small quantity of brandy in a glass of water has generally appeared to be the most congenial beverage at the meals. The administration of nitric acid,* as suggested by Dr. Prout; or what appeared to be preferable, the nitro-hydrochloric acid, in small doses, in some bitter infusion; or, laxative mixture, as the mistura gentianæ comp., is, with minute doses of mercury, generally successful, if continued a sufficient length of time. There is an important fact connected with the administration of the nitro-hydrochloric acid, upon which I feel quite sure its success materially depends. The really active agent is not a mere mixture of the two acids

* The exhibition of acids in some forms of dyspepsia has received, of late, most interesting explanation from the researches of Jolly and Graham, as considered by Lehmann. Jolly found by experiments the endosmotic qualities of acid are in proportion to those of alkalies as 0·350 to 215·725, and according to Graham, the diffusibility of acids was extremely great, that of alkalies very small. We know that free acid is commonly found as far as the middle of the ileum, notwithstanding the excess of the pancreatic juice and the bile; and its use evidently appears to be to promote the endosmotic current from the cavity of the intestine, and consequently resorption of the soluble constituents of the chyme.

(such as may be obtained by ordering a combination of the diluted acids), but is the peculiar compound, the so-called *aqua regia* arising from the mutual decomposition of the two acids. Hence they should always be prescribed in the proportion of one part nitric, and two or three of hydrochloric acid, with a direction for them to remain together for at least a few minutes before being diluted to the proper extent for administration in medicine. Where great nervous irritability exists, the sulphate of zinc is often of great service. It should be given in graduated doses, beginning with one grain, thrice a day, increasing the dose every third or fourth day until 18 or 20 grains are taken daily. The addition of a grain or two of ext. hyosciami or camphor often enables it to be better borne. The shower-bath, by acting in a similar manner, has been also of great service. Where the patient is anæmiated or chlorotic, the salts of iron in large doses appear to be of great use, not only by subduing the irritable state of the nervous system, but by increasing a healthier condition of the blood. No preparation of this important drug succeeds better than the ammonio-citrate or ammonio-tartrate in doses of seven or eight grains thrice a day, dissolved in a glass of water. The headache occasionally following the use of iron is readily prevented, and the success of the remedy ensured by taking it directly *after* a meal, so that it may be assimilated with the food.

250. In a few obstinate cases, resisting all other treatment, I have prescribed colchicum with advantage. The influence of this remedy in often checking a long-continued formation of uric acid has been already alluded to (159). And in some cases, where copious deposits of oxalate of lime existed, they have, under the influence of this drug, become replaced by uric acid or urates, thus inducing a

condition of urine much more amenable to treatment. The rationale of the action of colchicum is probably traceable, not to any specific power it exercises over any form of urinary deposit in particular, but rather in the influence it exerts over the secreting functions, controlling the action of the heart (on which it appears to act as a direct sedative), and consequently the capillary circulation, the very seat of secretion.

The circumstance of the replacement of oxalate of lime by uric acid or urates, under the influence of the colchicum, may be regarded as evidence of its influence on the capillary system in inducing the formation of normal products from the disintegration of effete and exhausted tissues during the process of secondary assimilation.

251. Occasionally some very painful cases present themselves in which all the symptoms above enumerated are present in an almost exaggerated form; the nervous system being excessively irritable. The patient often then presents the sallow aspect, the occasionally flushed face, and the emaciation so generally indicative of organic disease, yet on the most careful examination none can be elicited. I have repeatedly seen cases of this kind which gave me great anxiety, fearing that some serious lesion had escaped attention; and yet, with the exception of the copious elimination of oxalate of lime with urinary extraction, no indication of disease could be elicited. The subsequent recovery of the patient (often indeed very tedious and protracted), has, however, proved the absence of the dreaded organic mischief. Within these few days, I saw a gentleman who consulted me from Yorkshire, three years ago, with all these symptoms; his emaciation increased at one time to such an extent he could hardly walk. He appeared to be almost poisoned by the oxalic

acid circulating in his blood, and, although now quite well, the disease did not completely yield for nearly two years.

252. I have selected the following cases merely on account of their illustrating the chief varieties of ailments in which I have met with the oxalate, more than for the sake of pointing out the treatment. They may be regarded as illustrations of the set of symptoms most generally occurring in the cases in which large quantities of oxalate and oxalurate of lime appear in the system. It would be easy to fill a volume with accounts of cases of this kind; but they would be quite out of place in a work of this character. I only trust that they will appear of sufficient importance to draw attention to the subject generally, and to impress the profession with the fact of the very frequent, and very generally overlooked, production of oxalic acid in the animal economy.

I would beg to refer to a very excellent paper on the various symptoms associated with oxaluria by Dr. Begbie, in the 'Edinburgh Monthly Journal' for August, 1849. A paper of peculiar value, not less from the care evidenced in it in the observance of facts, than in the sphere of observation being so different from that from which my own experience has been drawn.

ILLUSTRATIVE CASES.

CASE I.—*Intense hypochondriasis; emaciation; copious discharge of crystals of oxalate of lime, with excess of urea.*

On Feb. 15th, 1842, I was consulted by Mr. W. Stone, in the case of a gentleman residing in a densely populated district in this metropolis. He was a remarkably fine man, about thirty years of age, of dark complexion, and whole expression strongly characteristic of deep melancholy; he was highly educated, and appeared to have painfully susceptible feelings. It appeared from his history that, until within the last four years his health had been excellent; at that time he contracted a sore, which was regarded as syphilitic, and so treated with, *inter alia*, abundance of mercury and iodine, which appeared to have aided in bringing on an extremely cachectic condition. Partially recovering from this, he left England on an eastern tour. During his wanderings he underwent treatment for what he regarded as a return of venereal symptoms, apparently only manifested by relaxation of the throat producing hacking cough. At the latter place he fell under the care of Dr. Mac Guffog, who evidently took a very correct view of the case, and he received decided benefit from his treatment. At last, wearied and dispirited, with an irritable throat, bearing about with him what he regarded as a venereal taint, and tired with wandering, he returned to England, a prey to the most abject hypochondriasis. When I saw him, his naturally expressive countenance indicated despair: he complained bitterly of the inefficacy of medicine, and seemed only in doubt whether he were doomed to die of syphilis or phthisis. The pulse was quick and irritable; tongue morbidly red at the tip and edges, and covered in the centre with a creamy fur. He had lately lost much flesh; he was troubled with a constant hacking cough, which

evidently depended on an enlarged uvula; for on examining the chest I could not succeed in detecting any evidence of disease. There was extreme palpitation, increased by eating and by exercise, much flatulent distension of the colon, with pain between the shoulders, across the loins, and over the region of the stomach; extreme restlessness, and nervous excitement, accompanied every action. The bowels were inclined to be constipated; urine copious; appetite rather voracious, but unsatisfying; skin acted imperfectly.

Feb. 15th.—The urine passed last night was acid, pale, of specific gravity 1·0295, contained much mucus, with abundance of flesh-coloured urates in suspension. On warming a portion, so as to dissolve the latter, a very copious crystalline deposit of oxalate of lime, in *cuboid* crystals, was rendered beautifully visible by the microscope. A large excess of urea was present, the addition of an equal bulk of nitric acid rendering some of the urine placed on a watch-glass nearly solid in ten minutes. The urine passed this morning was precisely similar.

℞ Acid. Nitrici dil., Acid. Hydrochlor. dil., aa ʒss; Inf. Serpentariæ, ℥xj;
Syr. Zinzib., ℥j. M. capt. ℥j, ter die.
℞ Ext. Aloes Pur., gr. ij; Conf. Opii, gr. iij. M. ft. pil. o. n. s.
Allowed a bland nutritious diet, with three glasses of old sherry daily: no vegetables, butter, or sugar.

27th.—Continued the treatment up to this date with very marked improvement; his expression was now cheerful; bowels acted freely and healthily; pain much less; skin active; throat not so troublesome.—Pergat.

The night urine was now of lower specific gravity, being 1·020, scarcely containing an excess of urea; a slight deposit of urates was present, mixed with but a small quantity of oxalate of lime in crystals. The morning urine contained less of the oxalate.

He continued this treatment patiently and persistently until March 20th, when he was so much better that he desired to take a country trip. I discontinued his medicines, and ordered him a mild tonic aperient occasionally.

May 1st.—I again saw this gentleman. He had gained strength, flesh, and spirits; he only complained of occasional headache, and a dread of a return of his ailment, and was anxious to break through his restrictions of diet. The urine now contained no excess of urea, and was nearly free from oxalate of lime. An occasional aperient was ordered for him.

June 4th.—He again called upon me; he was free from disease, and his most pressing evil seemed rather to arise from a lurking dread of phthisis than aught else. The urine was natural.

CASE II.—*Intense lumbar pain following exposure to cold; diuresis; great hypochondriasis: copious discharge of oxalate of lime following, and succeeded by uric acid gravel; excess of urea.*

Mr. F—, æt. 53, a gentleman residing in the suburbs, came under my care May 1st, 1842, complaining of intense pain across the loins, so severe as to interfere materially with his comfort. From his history it appeared that the general health had been good; always had an excellent, indeed often a voracious appetite, and been "a heavy feeder," eating and drinking abundantly, but scarcely ever had been intoxicated. His life had been one of great activity, being daily for several hours out on horseback or in his gig. Ten years ago he became the subject of severe irritative dyspepsia, lasting about six months: from this he recovered, and remained tolerably well for four years, when he suffered a relapse, attended with severe pain in the left hypochondrium, referred, by the late Mr. Vance, under whose care he then was, to flatulent distension of the colon, consequent on constipation. This pain had since been more or less constantly present, and was generally relieved by an escape of flatus. About five years ago he went to Cheltenham on the outside of a coach, and got chilled. He soon became the subject of severe lumbar pain, which, although frequently varying much in severity, had now left him. It was greatly increased by all indiscretions in diet, and when absent a hearty meal would at any time bring it on; when present it completely crippled him. By making a powerful effort he could sometimes manage to walk: and this generally gave some amount of relief, although too much exercise would always bring it on. He felt no increase of pain when riding on horseback, but a short drive on a coach would bring on a paroxysm of lumbar pain. Neither headache nor sickness had been present during the whole illness. The urine was generally turbid, and occasionally passed in larger quantities than natural. This gentleman had of late become subject to the most distressing hypochondriasis, looking at all occurrences as tinted with a colouring of melancholy or misfortune. So far as I could learn, the sexual powers had not become materially impaired. He had never had pains along the ureters, and inherited no tendency to calculus or gout. The tongue was tolerably clean, having in its centre a mere creamy layer. The bowels acted well.

May 1st.—The urine passed last night was pale amber-coloured; it contained much mucus, was acid, did not coagulate by heat; it contained in diffusion a large quantity of urates, which, on the application of heat, dissolved, and left a copious deposit of lozenges of uric acid, mixed with cohering crystals of that substance in the form of crystalline gravel; its speci-

fic gravity was 1·026; it did not coagulate by heat, but contained an excess of urea; on the addition of nitric acid, it in a few seconds became filled with fine crystals of nitrate of urea.

The urine passed this morning was of specific gravity 1·024, and in other respects resembled the night urine.

℞ Hyd. c. Cretâ, gr. iss; Ipecac. Pulv., gr. j. Ft. pilula o. n. s.
Omit all beer and spirits, as well as fatty and indigestible articles of food. Plain diet, with animal food once daily.

8th.—Much the same; the bowels had acted with copious bilious discharges; pain still intense; depression very great. The urine passed last night was of specific gravity 1·030; it was acid, pale, contained abundance of urates, which, by heat, disappeared, leaving, distinctly visible under the microscope, a copious deposit of oxalate of lime in minute octohedra, mixed with an abundance of nucleated epithelium: no uric acid. On the addition of nitric acid, the urine almost immediately solidified from the copious crystallization of nitrate of urea.

The morning urine was of specific gravity 1·027. It contained a great excess of urea, and resembled the night urine in every particular, except that the urates were tinted with pink, and the crystals of oxalate of lime were much larger, being fine octohedra.

℞ Acidi Nitrici, ♏iij; Acidi Hydrochlorici, ♏vj, ter in die ex cyatho Inf. lupuli, sumend.

9th.—The urine was sent to me; that passed last night was healthy in colour; quite limpid; sp. gr. 1·027. Under the microscope it appeared full of fine octohedra of oxalate of lime. That passed this morning resembled it in everything, save in its lower specific gravity, being 1·021. Both contained excess of urea.

16th.—Very much improved. He had been quite free from pain for several days; was in excellent spirits. He had taken more exercise, having been out rook-shooting the whole week, and been "living well."

Last night's urine was of specific gravity 1·022. No visible deposit. Under the microscope a few small octohedra of oxalate of lime, mixed with "cylinders" of uric acid, were visible. The specimen passed this morning was of sp. gr. 1·017, and contained still fewer crystals of the oxalate.

23d.—Appeared completely well in health and spirits; he was now cheerful

and free from pain. The urine passed this morning contained no oxalate; had a slight deposit of uric acid in lozenges, but was still rather too high in specific gravity, being 1·024.

Oct. 2d, 1845.—This gentleman again came under my care, having enjoyed excellent health since I had last seen him. He had become the subject of "a fit of gravel," ending in the passage of several very minute uric acid calculi.

Aug. 8th, 1850.—I again saw this patient labouring under irregular gout, from which he quickly recovered.

CASE III.—*Irritative dyspepsia, gastrorrhœa, great emaciation and depression, voracious appetite, copious deposit of oxalate of lime in large and well-defined crystals.*

M. W., æt. 35, came under my care April 26th, 1842: a pallid nervous woman; had one child nineteen months ago; suckled it during nine months; previous to this had suffered from four miscarriages, losing at each a large quantity of blood; had no leucorrhœa. Previous to her first pregnancy her health had been excellent. During the last year she had been rapidly losing flesh, and her energies were almost prostrate, the spirits being intensely depressed. She had, for a long period, suffered from pain at the scrobiculus cordis and gastrorrhœa. For several months her most serious evil had been a fixed persistent pain across the loins, became much more intense by exertion. No evidence of uterine disease; bowels constipated; appetite craving, and distressing, never being satisfied; thirst great; flatus considerable.

26th.—Shortly after each meal a gush of limpid fluid rose from the stomach, which, in about an hour after, was followed by the vomiting of the meal in a semi-digested state, mixed with a considerable quantity of black grumous matter; bowels confined.

Pil. Col. c. Hyd., ℈ss, o. n. s.

30th.—Bowels freely open; vomiting considerable and distressing, accompanied with great pain at the epigastrium.

Pil. Cal. c. Opii, j; ante prandium quotidie; M.M. c. M.S., ℥ss, c. Acid. Hydrocyan. dil., ♏v, t. d.

May 5th.—Bowels freely open; vomiting not so frequent; complained of severe pain, referred to the right side of the chest.

Rep. Mist.

℞ Bismuth. Trisnitratris, Conii fol. Sodæ Carbon. sic., aa g. iv, t. d.

10th.—Was suddenly seized last night with fainting, and severe pain in epigastrium. This was relieved by a little brandy and water. After a short time sleep came on, and she awoke somewhat relieved. The emaciation had rapidly increased during the fortnight. I now requested her to send me a specimen of the urine passed in the evening. It was pale, of sp. gr. 1·030, acid and turbid from the presence of flesh-coloured urates. On exposing a portion to heat, the latter dissolved, and a white opaque deposit was left; this, under the microscope, was found to consist of oval epithelial scales, mixed with very fine and large octohedra of oxalate of lime.

Perstet in usu pulverum; Ammoniæ Sesqui-carbonatis, gr. iv.; ex. Inf. Serpent., ℥j; et Sp. Eth. Sulph. co., ʒss, ter in die.

11th.—Passed a good night; no pain either in back or epigastrium; much headache; bowels thrice open from a dose of rhubarb she had taken this morning; motions offensive; no sickness since yesterday; felt comfortable, but weak; urine clear; oxalate of lime not so abundant.

Mis. Effervescens c. Syr. Papav., ʒj, 4tis horis.

12th.—Vomited yesterday after dinner; passed a good night; complained this morning of pain all over the abdomen, and between the scapulæ; bowels acting freely.

Pergat. Fotus Papaveris abdomini.

16th.—Decidedly improving; could now bear on the stomach a light meal of animal food: complained bitterly of pain across the abdomen, compared to a cord tightly drawn round it.

℞ Sp. Ammon. Arom., ♏xx; Inf. Serpent., ℥j; Syr. Papav., ʒj. M. ter in die.

21st.—Improving; was gaining flesh and spirits; complained of gastrodynia daily after dinner.

Pergat. Pil. Cal. c. Opii, j, bis die.

27th.—Had gained strength enough to walk from Hoxton, where she resided to my house; was very much better, but still had great lumbar pain. The

urine was still of rather too high a density, contained an excess of urea, and tolerably copious deposit of crystals of oxalate of lime.

℞ Inf. Serpent., ℥j; Acid. Nitrici dil., Acid. Hydrochlor. dil., aa ♏v. M. ter die. Allowed to take some porter.

29th.—Much improved; urine copious, pale, sp. gr. 1·009.

June 7th.—Convalescing; urine 1·019, free from oxalate.

13th.—Had suffered a slight relapse, attended with returns of lumbar pain, following her taking a glass of hard porter. This lasted but a few hours; and she intended leaving town to recruit her strength in the country.

Case IV.—*Emaciation; extreme melancholy, following great mental distress; severe lumbar pain; great excess of urea, and discharge of oxalate of lime; remarkable gelatinization of the urine by heat.*

C. C., æt. 39, a tall, thin woman, of fair complexion, presenting the appearance of great emaciation, came under my care on May 3d, 1842. She had been a widow four years; had had two husbands, and lost both by phthisis; this, with her depressed circumstances, had caused her to experience great mental and bodily distress. She had had eight children of which she had lost six. Menstruation still regular, but, to use her own expression, almost drowned in leucorrhœa; bowels habitually constipated. She stated that she had for two years been gradually losing flesh; but lately this had so increased as to amount to rapid emaciation. Her depression and melancholy were intense, probably, however, partly arising from her being dependent on dressmaking as the only means of support. For some months past she had been the subject of almost constant "wearing" pain across the loins, increased by exercise, and so severe at night as to prevent her lying in the recumbent position. The pain was always increased by exercise. Her nights were usually sleepless; and if she did get a little rest, she started from it with the most frightful dreams. She had frequent palpitations, and pain about the epigastrium after taking food; no great amount of flatulence; tongue red at the tip and edges, white fur in the centre.

Pil. Col. c. Hyd., ii, o. n. s.; Emp. Belladonnæ regioni cordis.

May 6th.—The urine passed last night was of sp. gr. 1·027, acid, and

turbid from its holding urates in diffusion. On decanting the clear portion, and gently heating the opaque part, the urates dissolved, and left a copious deposit of microscopic octohedra of oxalate of lime, and numerous scales of nucleated epithelium. No change was produced in this urine by heat. The specimen passed this morning was of sp. gr. 1·011, very pale and limpid. It became opaque on the application of heat; the troubling not being removed by nitric acid. It scarcely contained a trace of oxalate of lime. I ordered all medicines to be omitted, for the purpose of watching the state of the urine for a few days.

8th.—Bowels for three days had been confined. She complained of a sense of distension in the abdomen, and had for two days been confined to bed with intense headache, giddiness, and feverish excitement.

Morning urine clear, 1·028, acid; no oxalate.

Night urine contained a mucous cloud, 1·022, abundance of oxalate of lime in octohedral crystals.

Pil. Col. c. Hyd., ij, 6tis horis ad catharsin.

9th.—Last night's urine turbid from the presence of urates; felt very weak.

Mist. Gent. Co., ℥j; c. Sp. Ammon. Arom., ♏xx, ter in die.

13th.—Much the same; constipation continued.

Pulv. Jalapæ Co., ʒj, o. m. s.

15th.—No change for the better; bowels had acted well; she still felt wretchedly ill and depressed.

The urine passed last night was of a density of 1·028, acid, pale, and contained in suspension the fawn-coloured urates. On warming a portion, the urates dissolved, and the clear fluid soon let fall a white deposit, which, on decanting the still warm liquor, and examination under the microscope, was found to consist of various sized octohedra of oxalate of lime, mixed with myriads of oval nucleated epithelial scales. During the application of heat, the urine underwent a remarkable change. It did not become opaque, or coagulate, but assumed a gelatinous consistence, retaining its transparency. It then required violent agitation to diffuse it through water. This effect, at the time new to me, I have since repeatedly observed, and it seems to chiefly

arise from the urates combining with the water, thus forming a gelatinous hydrate.

The morning urine was of sp. gr. 1·030, contained an abundance of epithelium, but no oxalate. Both specimens were loaded with urea, and were converted into nearly semi-solid crystalline masses on the addition of nitric acid.

Rep. medicamenta.

17th.—Improving; bowels acted well, and leucorrhœa decreasing; general health better; the symptoms of uterine irritation had decreased with the leucorrhœa, but the want of strength, emaciation, depression, and severe lumbar pain, continued; the oxalate of lime still abundant in the night urine.

Acid. Nitric. Dil., ♏xv; ex Dec. Cinch., ℥j, bis die. Ordered nutritious diet, avoiding vegetables and beer, weak gin-and-water at dinner.

June 1st.—Had been, during the last week, completely free from lumbar pain; this morning, apparently owing to an indiscretion in diet last evening, had a slight return. The urine passed last night just before going to bed was pale, of specific gravity, 1·015, contained abundance of epithelial scales, and no visible oxalate.

Rep. omnia.

5th.—The return of lumbar pain had been quite evanescent; she was now quite free; complained of debility and occasional headache; still suffered from constipation; skin acted well; occasional feverish flushes, especially in the evening. The urine passed last night had increased in specific gravity to 1·029; it was loaded with pale urates; it contained no oxalate of lime, and, by heat, underwent the remarkable gelatinization before referred to.

Rep. Mistura—Sumat. Pil. Col. c. Hyd., ℈ss, p. r. n.

12th.—By taking the pills on alternate nights, a tolerably healthy action of the bowels had been kept up; she was much improved; the flushes were less frequent; no return of lumbar pain; merely complained now of not feeling quite strong.

Inf. Serpentariæ, ℥j, t. d. Allowed a little porter.

13th.—The urine passed last night was of a density of 1·028, healthy in colour, contained no visible deposit, save a mucous cloud. The microscope, however, detected a considerable deposit of octohedral crystals of oxalate of lime, with an immense quantity of oval nucleated epithelial scales.

Ordered to omit the porter.

26th.—Felt quite well. The oxalate had again disappeared.

CASE V.—*Rapid emaciation and depression; nervous palpitations; lumbar pain; excess of urea, and discharge of oxalate of lime.*

J. B., æt. 31, came under my care June 3d, 1842.

A tall and remarkably fine man, extremely emaciated, his cheeks hollow, and his whole appearance resembling that of a diabetic patient. He was a currier, and was exposed to extreme alternations of temperature, working in a half-bent position, without coat or waistcoat, in a shop through which were constant currents of air. He was unmarried, and had been very irregular with regard to women; for two years he had been gradually losing flesh, strength, and spirits; his sexual powers had also rapidly declined, and now scarcely existed; he had frequent seminal emissions in his sleep, which left him weak, exhausted, and melancholy, during the ensuing day. Regarding his previous habits, *he* considered he had been temperate, rarely getting intoxicated more than twice a week, and then on porter or ale. During two months his decline had been rapid,—a *facilis descensus.* He had now an almost constant headache, a constant aching pain across the loins, a sense of sinking at the stomach, as if, to use his own expression, he had no inside, frequent chills, with cold clammy sweats, succeeded by feverish flushes; tongue red at the tip and edges, with a white central fur; frequent giddiness; his memory had been for some time failing. His nights were wretchedly restless, generally tossing all night from side to side, in vain endeavouring to sleep, and if he slumbered he awoke as fatigued as when he retired to rest: appetite bad; no thirst; frequent palpitation and flatulence; pulse small and irritable; no chest-disease.

Sumat. Pulv. Rhæi Salin., ʒj, cras mane.

5th.—Bowels acted once yesterday from the powder; hands tremulous. The urine passed last night was deep amber colour, acid, of a density of 1·030, no visible deposit; by microscopic examination, however, myriads of

splendid octohedral crystals of oxalate of lime became visible. On the addition of nitric acid to the urine, a copious formation of crystals of nitrate of urea occurred.

The urine passed this morning was paler, acid, of a density of 1·025, and contained less oxalate and urea.

> Pil. Col. c. Hyd., ij, o. n. s.; Acid. Nitric. dilut., ♏xv, ter die, ex. Dec. Cinchonæ, ℥j. Nutritious diet, light pudding daily, no beer, weak brandy-and-water at dinner.

15th.—Bowels acted thrice daily; motions offensive and dark coloured; complained greatly of palpitation of the heart.

> Rep. Mist. c. Inf. Serpentariæ, vice Dec. Cinchonæ.

The urine passed last night was deep amber-coloured, of specific gravity 1·028: the microscope detected myriads of smaller octohedra than before. The morning urine was of a density of 1·018.

28th.—Very much improved; rested better at night; no lumbar pain; great sense of sinking at the scrobiculus cordis. Night urine, 1·026, deposited phosphates by heat, and contained numerous minute crystals of oxalate of lime. Morning urine 1·026 like the night specimen, but did not become opaque by heat.

> M. Ferri Co., ℥j; c. Tr. Lyttæ, ♏x, b. d.

July 2d.—Improving; seminal emissions ceased. Still copious octohedra in the night urine, which was of the density 1·025.

> Sumat. Vin. Colch., ♏x, ex. Mist. Gent. Co., ℥j, b. d.

10th.—So much better that he was anxious to leave London on a long journey; the urine was now free from oxalate.

CASE VI.—*Discharge of oxalurate (?) of lime, apparently succeeding to mechanical injury.*

D. M—, æt. 58, came under my care May 25, 1842: a pallid-looking man, with a face, although not remarkably attenuated, presenting a gaunt hollow aspect with a slight hectic flush over each cheek bone; engaged up to the age of 32 as a ship's carpenter, in vessels chiefly in the Mediterranean, and once

in a privateer on the American coast; during this time his life was one of great intemperance, drinking rum abundantly. Since he had left the navy he had worked as a cabinet-maker. In 1831, whilst lifting a heavy weight, he experienced a "wrench" across the loins, the effects of which injury, although apparently not severe at the time, had ever since, more or less, annoyed him; although his general health, up to the last year had been tolerably perfect.

His chief ailment now consisted in a gradual, but persistent loss of strength and health during the last twelve months, during which period he had lived more regularly than previously. He was very low-spirited; his memory had of late become defective; perspired freely on the slightest exertion; had frequent nausea at the sight of food; appetite bad; no pain in the stomach after the meals; no acid or bitter eructations; great and frequent flatulent distension. His nights were wretched and restless. During the last year, a fixed and constant pain across the loins had distressed him; this he could succeed in *walking off* for a time, but fatigue would eventually increase it; the bowels had, of late, been relaxed, acting three or four times a day, the motions being dark and fluid; his sexual appetite and powers had of late rapidly declined; frequent involuntary seminal emissions appeared at night; the tongue was clean, vividly red, and polished at the tip and edges; pulse full and hard, but jerking. The urine passed on the night of May 25th was clear, amber-coloured, acid, of specific gravity 1·017, and contained no visible deposit; a drop of the lower stratum of the urine, after repose, was full of dumb-bell crystals, which were hard and somewhat gritty, unaltered by boiling acetic acid, but readily soluble in nitric and hydrochloric acids. The specimen passed in the morning resembled the last; was of the density of 1·012; it let fall a slightly cloudy deposit by repose, which, under the microscope, was found to be made up of myriads of minute cuboid crystals of oxalate, mixed with a very few dumb-bells.

℞ Acidi Hydrochlorici, ℨiij; Acidi Nitrici, ℨj; Mist. Camphoræ, ℥iiiss; M. capl. cochl. j, min.; ex. Inf. Anthemidis, ℥iss, ter die; Sumat. Pil. Hydr. Chlor. Co. gr. v. o. n. He was ordered to wear a flannel bandage round the loins, to keep to a bland nutritious diet, omitting all fermented liquors.

27th.—Night urine clear, amber-coloured, no visible deposit, 1·016, very acid, no opacity by heat; some white pearly granules became visible by repose, which consisted of cohering dumb-bell crystals. Morning specimen pale, contained mucous clouds, with some flakes of uric acid mixed with cohering dumb-bells.

June 2d.—Notwithstanding the warm weather, he had not perspired so much as usual; bowels acted once daily; motions dark and tolerably healthy; urine in less quantity; that passed at night, 1·019, pale, and had a copious deposit of "cylinders" of uric acid, mixed with lozenges and rosettes, nearly free from oxalate of lime. The morning specimen was 1·018 in density, and perfectly resembled that passed at night. He got better nights' rest; lumbar pain still severe, but altogether felt stronger.

9th.—Tongue not so vividly red; gums slightly affected. Has been drinking cider, which not appearing to disagree, I have permitted him to continue. The night urine is of density 1·024, and contained a curious deposit of uric acid.

Rep. Mist.; omitte pil.

23d.—Improving manifestly in general health; no sickness; bowels acted well. Night urine 1·018; morning 1·015; no visible deposit; felt only weak and nervous.

Zinci Sulph., gr. ss., c. Conf. Opii gr. iij, formâ pilul., ter die.

30th.—Convalescing; had now only a pain in the back, chiefly confined to the spine, from the first lumbar vertebra to the sacrum; this was not constant, but came on after fatigue in the evening; still complained of frequent involuntary seminal emissions at night. He was ordered to continue his zinc, and to have cold water copiously applied in a stream from a kettle over the genitals and loins twice a week.

Case VII.—*Copious secretion of oxalate of lime; over lactation; probable existence of calculus in the right kidney.*

M. R., æt. 37, came under my care, December 14, 1843; a pallid thin woman, the mother of two children; had been for years ailing from vague pains connected with irritable uterus. Eighteen years ago, whilst in service, she received a violent blow in the right hypochondrium, and had never since been free from more or less persistent pain in that region, extending to the right kidney. From the period when she received the blow, she had, at each return of the catamenia, been jaundiced, and was generally relieved by spontaneous billous vomiting. Every two or three months she suffered severe paroxysms of pain in the region of the right kidney, lasting three or four days, and relieved by a copious discharge of very turbid urine, attended with great irritability of the stomach, no hæmaturia. After one of these attacks she brought me the urine.

Night urine—pale, acid, specific gravity 1·025 with a copious deposit of urates, which vanished on the application of heat, and left undissolved an immense number of the largest dumb-bell crystals I ever saw.

Morning urine—clear; by heat a scanty deposit of phosphates fell; much epithelial debris; no oxalate. Ordered her a generous diet, and to wean her infant, who was thirteen months old; no medicine.

December 18th.—Had suffered much from sickness; pains over the right kidney less defined; bowels acted well; felt extremely weak and depressed; probably owing to over-lactation.

℞ Acidi Nitrici, ʒj.
—— Hydrochlorici, ʒiss.
Inf. Gentianæ co., ℥iss. M. Ft. guttæ.
Capt. coch., j, parv. ter die ex aquæ cyatho.

She continued this treatment persistently until February 20th; the oxalate of lime gradually disappeared, and she appeared tolerably well.

I again saw this patient in June; she had still frequent returns of renal suffering, with occasional discharge of oxalate of lime; her general health remained good. There was but little doubt of the existence of a calculus of oxalate of lime in the right kidney.

CHAPTER X.

CHEMICAL PATHOLOGY OF THE EARTHY SALTS.

(*Phosphuria.*)

(Phosphate of Lime, Ammonio-phosphate of Magnesia, and Carbonate of Lime.)

253. We have already seen that a considerable quantity of phosphoric acid is excreted from the blood by the kidneys in the course of twenty-four hours, divided between four bases, soda, ammonia, lime, and magnesia,

forming, in all probability, the three following salts, whose composition has been already pointed out:

Ammonio-phosphate of soda.
Phosphate of magnesia.
Phosphate of lime.*

The first of these is readily soluble in water, and on the hypothesis I have ventured to suggest (81), is of importance as the solvent of uric acid, and probably is indirectly the source of the acidity of urine. The other two salts are nearly totally insoluble, although the presence of a very minute portion of almost any acid, even the carbonic, enables water to dissolve a considerable quantity. They are besides soluble, to a certain extent, in hydrochlorate of ammonia, and possibly may sometimes exist in the urine thus dissolved. In healthy urine, the earthy phosphates are held in solution by the acid of the super-phosphates, produced by the action of uric (or hippuric) acid on the tribasic alkaline salts (79); and these salts are also, according to Enderlin,[69] capable of dissolving a certain quantity of phosphate of lime. The physiological source of the phosphates has been already pointed out.

254. It has been already stated that the earthy phosphates are always abundant after a meal, and that the reverse applies to the alkaline salts (109). Phosphoric acid, it must be recollected, may be excreted in large

* To these salts must be added the neutral and acid phosphates of soda, the presence of which is asserted by Robin and Verdeil, and confirmed by Dr. Hassall. Lehmann states, on the subject of the presence of ammoniacal salts in the urine, that the hydrochlorate of ammonia, *phosphate of soda and ammonia*, and phosphate of magnesia and ammonia do not occur in fresh urine. The experiments upon which this opinion is founded I have previously given.

excess without forming a deposit, in consequence of its being combined with an alkaline base, and hence when the secretion of an excess of phosphoric acid is to be looked for, it can by no means be indicated by the amount of earthy salts deposited. There is always three or four times more phosphoric acid in a given specimen of urine in the form of a soluble alkaline salt, than is precipitated as an insoluble earthy compound. Indeed, the presence of an excess of lime and magnesia has more to do with determining a deposition of insoluble phosphate than an excess of phosphoric acid. Still, a large amount of valuable information can be obtained by observations founded on the deposits of earthy phosphates, and as in very many cases the circumstances under which these salts are deposited often constitute the elements of various diseases, the quantity of phosphatic deposits becomes of very great importance.

Diagnosis of the Earthy Phosphates.

255. Deposits of these salts are always white, unless coloured with blood; soluble in dilute hydrochloric acid, and insoluble in ammonia or liquor potassæ. On heating the urine, the deposit undergoes no further change, except agglomerating into little masses. Mucus, pus, and blood, are often present in the urine, and mask the chemical characters of the deposit.

256. If a very *small* quantity of a solution of sesqui-carbonate of ammonia be added to a *large* quantity of healthy urine, the mixture becomes turbid from a deposit of the triple phosphate, mixed with some phosphate of lime. On placing a drop of this turbid urine under the microscope, myriads of minute prisms of the triple salt

(264), mixed with amorphous granules of the phosphate of lime, will be seen floating in the fluid, these readily disappear on the addition of a drop of almost any acid. As these earthy salts are insoluble in water, it is evident that they must be held in solution in the urine by the free acid which generally exists. If from any cause the quantity of solvent acid falls below the necessary proportion, the earthy phosphates appear diffused through the urine, disturbing its transparency and subside, forming a deposit. Hence, whenever the urine is alkaline, phosphatic deposits are necessary consequences. If urine be secreted with so small a proportion of acid as barely to redden litmus paper, a deposit of triple phosphate often occurs within a few hours after emission; a phenomenon probably depending partly on the influence of the mucous matter present, which, readily undergoing change, acts like a ferment, induces the decomposition of urea, and the formation of carbonate of ammonia (274), which, by neutralizing the solvent acid, throws down the phosphates. The precipitation of the phosphates thus takes place in a manner analogous to that in which carbonate of lime is thrown down, the action being, however, here limited to a neutralization of the free acid; indeed, where phosphate of lime forms the great bulk of a deposit, a certain portion of carbonate is generally present.

The triple phosphate which is precipitated artificially from urine by means of a very small quantity of sesquicarbonate of ammonia, and which occurs spontaneously in prismatic crystals (264 A), is a neutral salt, and may *co-exist as a deposit with a very sensible acidity* of the supernatant urine. It by no means follows that the existence of a deposit of this salt involves the necessarily alkaline state of the urine.

257. There is, however, another triple phosphate

produced artificially by the addition of an *excess* of ammonia to urine, and which is of frequent occurrence in the fluid when in an alkaline or putrescent condition. This differs from the former salt in containing an excess of base, and cannot possibly be present in urine which exerts the slightest acid reaction on litmus paper. The crystals are quite characteristic, being invariably stellar or foliaceous (264 D). This salt is termed the basic phosphate, but the chemical distinctions between this and the prismatic salt are very unsatisfactory. I am aware of but one chemist who has given formulæ for the two salts, but in a manner so opposed to the known habitudes of phosphoric acid as to authorise their rejection. The composition of the ammonio-phosphate of magnesia previously given (106) applies to stellar salt. The *probable* constitution of the two salts is—

In the neutral or prismatic salt (dry) $= (H\,O, N\,H_4\,O, Mg\,O,) + P_2\,O_5$.
In the basic or stellar salt (dry) $= (N\,H_4\,O, 2\,Mg\,O,) + P_2\,O_5$.

258. The phosphate of lime, which is often precipitated with the neutral, and always with the basic triple salt, is not quite so readily soluble in very dilute acids as the two latter, and hence, when a mixed deposit of the calcareous and magnesian phosphates exists, the phosphate of lime is but slowly acted upon when digested in very dilute acetic acid, which readily dissolves the magnesian salt. When the triple or calcareous phosphates are separately exposed to the heat of a blowpipe flame, they fuse with great difficulty, and not until the heat has been urged to the utmost. If, however, the phosphate of lime is mixed with a triple phosphate in about equal proportions, they readily melt into a white enamel. These mixed salts constitute what is hence termed the fusible calculus, and

they can be readily detected by this property in concretions; a character very available in the examination of gravel and calculi, as the two phosphates generally occur together.

259. The physical appearance presented by deposits of the earthy phosphates varies extremely; sometimes, especially when the triple salt forms the chief portion of the deposit, it falls to the bottom of the vessel as a white crystalline gravel. If but a small quantity of this substance be present, it may readily escape detection by remaining for a long time diffused through the urine; after a few hours' repose some of the crystals collect on the surface, forming an iridescent pellicle, reflecting coloured bands like a soap-bubble or a thin layer of oil. If, then, the lower layers of the urine be placed in a watch-glass, and held obliquely over the flame of a candle or any strong light, a series of glittering points will become visible from the reflection of light from the facets of the minute prisms of the salt.

The phosphates will often subside towards the bottom of the containing vessel like a dense cloud of mucus, for which they are frequently mistaken. Not unfrequently they will, in very alkaline urine, form dense masses in the urine, hanging in ropes like the thickest puriform mucus, from which it is utterly impossible to distinguish them by the naked eye. Their disappearance on the addition of hydrochloric acid will at once detect their true nature. Where, as frequently occurs, a large quantity of ropy mucus, pus, or blood, coexist with the phosphates, no mode of investigation can be so satisfactory as the examination of a few drops of the urine between two plates of glass, by the microscope, when the characteristic crystals of the phosphates are readily recognised (264).

260. The phosphates are occasionally found mixed in a

deposit with urates; in this case the latter is always of a pale variety, and nearly white. It has, indeed, been stated that when urine deposits pale urates, it indicates a tendency to the deposition of the phosphates. This remark is so far true, that as phosphatic urine is usually very pale, it would follow as a necessary consequence that any urate deposited from it, would be nearly white from the absence of colouring matter to tint it of any other hue. Beyond the fact, then, that white urates are deposited by pale urine, and that phosphatic urine is often scarcely coloured, I am not aware of any circumstance authorising the belief of any necessary connection between them.

State of urine depositing earthy phosphates.

261. It is, as we have seen, by no means necessary for urine to be alkaline for a deposit of phosphates to exist (256); indeed, in the majority of cases, urine which deposits the triple phosphate is acid at the time of emission. This may appear rather paradoxical when we recollect the ready solubility of triple phosphate in a very weak acid; but admits of a ready explanation when the fact that a fluid may redden litmus, and still contain no uncombined acid, is borne in mind. Thus, some neutral salts redden litmus paper, and yet contain no free acid. And this fact may in some cases explain the occasional acid reaction of urine, where deposits of phosphates exist. It has been rendered very probable by the interesting experiments of my colleague, Dr. Rees,[48] that hydrochlorate of ammonia* may in some instances be really the solvent of the earthy phosphates when in

* The presence of this salt in fresh urine, as previously stated, is doubted by Lehmann.

excess, as they are to a certain extent soluble in solutions of this salt. These solutions possess the very remarkable property of becoming opaque by ebullition, from a deposition of a portion of the earthy salt. The very same phenomenon often occurs in urine which contains an excess of phosphates. Indeed, it is not unfrequent to meet with urine which does not contain any visible deposit, and yet on the application of heat appears to coagulate, not from the presence of albumen, but from the deposition of earthy phosphates. The addition of a drop of nitric acid immediately dissolves this deposit, and distinguishes it from albumen (315). A different explanation to this phenomenon has been offered by Dr. Hargrave Brett,[117] and undoubtedly is perfectly true in some cases. Dr. Brett's explanation is founded on the solubility of phosphates in water impregnated with carbonic acid. It has been long known that carbonic acid frequently exists in a free state in the urine, and in a large number of specimens examined by Dr. Brett and myself we succeeded in readily isolating it. These experiments were made several years ago, in consequence of our having noticed some curious phenomena presented by the urine of a student of Guy's Hospital (since dead), a pupil of the late Mr. Bryant, of Kennington. This gentleman, in endeavouring to raise a heavy sack of Epsom salts, strained his back, and soon after fell into a state of marasmus, with occasional hectic, which ultimately exhausted him. During the last six months of his life he passed a very large quantity of pale acid urine, which by keeping soon became alkaline. This urine was limpid when first passed, but became opaque as soon as it had cooled, still, however, retaining its acidity, so that the deposition of the phosphates did not necessarily depend upon the development of an alkali.

On warming the fresh urine an evolution of carbonic acid gas took place, accompanied by a deposition of phosphates. When two portions of the fresh urine were placed as soon as passed in separate bottles, one being left open, the other closely corked, the urine contained in the latter remained transparent, and that in the former became opaque.

262. Another explanation of the precipitation of the earthy salts by heat has been proposed by Dr. B. Jones.[139] He has shown, that if to any urine rich in phosphates, as that passed shortly after a full meal, a minute portion of an alkali, or of common phosphate of soda (tribasic) be added so as to neutralize any great excess of acid, the subsequent application of heat produces a precipitation of the earthy salts. If, therefore, a more than average proportion of the latter exists in a barely acid urine, their precipitation by heat would appear to be a necessary consequence.

263. The urine, in cases where an excess of phosphates of either kind exists, varies very materially in its physical character. Certainly no general rule can be assigned for the colour, density, or quantity of the urine secreted in these cases, taking them in a mass; although I think there are certain facts connected with the presence of the phosphatic deposits which serve to connect the colour and quantity of the urine with the pathological conditions producing, or at least co-existing with them.

As a general rule, where phosphatic deposits, whether magnesian, calcareous, or both, exist for a considerable time, the urine is pale, often whey-like, generally secreted in very large quantities, and of low specific gravity (1·005—1·014). This is especially the case where organic lesion of the kidneys exists. On the other hand, when

the deposits are of occasional occurrence, often disappearing and recurring in the course of a few days, the urine generally presents a deep amber colour, and is not only of high specific gravity (1·020—1·030), but often contains an excess of urea, and presents an iridescent pellicle on its surface by repose. This is especially the character of the phosphatic urine secreted under the influence of some forms of irritative dyspepsia, and where the phosphates themselves may be traced to mal-assimilation. A considerable quantity of prisms of triple phosphate are often found in the urine entangled in the meshes of a mucous cloud. This frequently occurs in the urine passed after an indigestible meal, especially after eating a large quantity of bread, and will often be observed for a day or two, and then disappear. Again, phosphatic urine may be met with, varying from a pale whey-like hue to deep brown or greenish brown, exceedingly fetid, generally but not constantly alkaline, and loaded with dense ropy mucus, often tinged with blood, and in which large crystals of the triple phosphate and amorphous masses of phosphate of lime are entangled. This variety is almost always met with, either under the irritation of a calculus, or even of a catheter worn in the bladder (277), or where actual disease of its mucous lining exists.

Microscopic characters of earthy phosphates.

264. A. *Prisms of neutral triple phosphates.*—These are always exceedingly well defined, the angles and edges of the crystals being remarkably sharp and perfect (fig. 51). The triangular prism is the form most frequently met with, but it presents every variety in its terminations. These are sometimes merely truncated,

often bevelled off, and not unfrequently the terminal edges are replaced by facets.

I scarcely know a more beautiful microscopic object than is afforded by a well-marked deposit of this salt. The different degrees of transparency presented by these crystals are very remarkable; generally they are so transparent as to resemble prisms of glass or crystal; sometimes presenting an enamel-like opacity, so that they can only be viewed as opaque objects. This change may be artificially effected by exposing the transparent prisms to a boiling heat. When preserved in balsam, they depolarize light, exhibiting a beautiful series of tints, when the axes of the tourmalines or calc-spars are crossed in the polarizing microscope.

B. *Simple stellæ of the neutral salt.*—These are in fact minute calculous concretions, and are generally com-

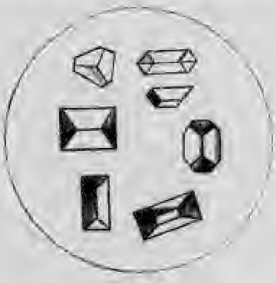

Fig. 51.

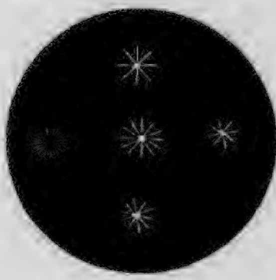

Fig. 52.

posed of acicular prisms cohering at one end, so as to represent simple stellæ (fig. 52). Not unfrequently they adhere so closely and are so crowded as to resemble rosettes. I have repeatedly seen small prisms crystallized like uric acid on one of the fine transparent hair-like bodies which are of frequent occurrence in urine (fibrinous casts of tubules). The crystals of the phos-

phatic magnesian salts are invariably colourless, never presenting the yellow or orange hue of uric acid.

C. *Penniform crystals of neutral salt.**—This very elegant variety of the neutral magnesian phosphate has occasionally fallen under may notice, and has occurred in a very few cases. It presents the appearance of striated feather-like crystals, two being generally connected so as to cause them to resemble a pair of wings (fig. 53). I cannot give any satisfactory explanation of the cause of this curious and elegant variety, nor whether these crystals differ in any way chemically from the prismatic form. The few specimens I have met with occurred in acid urine.

D. *Stellar and foliaceous crystals of basic salt.*—This variety, as I have already stated, cannot generally be regarded in any other light than as a secondary formation

Fig. 53.

Fig. 54.

taking place out of the body. When rapidly formed, this salt generally appears in the form of six-rayed stars, each ray being serrated, or irregularly crenate, often runcinate, like the leaf of the taraxacum (fig. 54). This,

* Dr. Hassall states, in the April number of the 'Lancet,' for 1853, that the penniform crystals are composed of phosphate of lime, and do not occur in fresh urine.

however, presents several subordinate varieties, depending, in all probability, upon accidental circumstances. When this salt is more slowly formed, as on the surface of the urine in pregnancy, it presents large and broad foliaceous laminæ, often so thin and transparent as to escape notice altogether, especially if viewed in too strong a light. I have, indeed, often overlooked them until I illuminated the specimen under the microscope with polarized light, when they start into view elegantly tinted with colours, in which pink and green are the most prominent.

E. *Phosphate of lime.*—I have never seen this salt in a crystalline form, but it has been said to occur in irregularly crystallized masses.[67] In all the specimens I have examined, no appearance of structure could be detected; the phosphate either resembling an amorphous powder, or collected in roundish particles often adhering to prisms of triple phosphate. The sediments of this substance are remarkably opaque, so that when even a minute portion is examined between plates of glass, the layer, however thin, and white by reflected, always appear yellow or brownish by transmitted, light.

Robin and Verdeil, in the twenty-ninth chapter of the second volume of their valuable work, state that the neutral phosphate of soda ($2NaO, HO, PhO_5, 26HO$,) is met with, without exception, in all the solids and fluids of the system, and that human urine contains both the neutral and acid phosphate of soda. Having remarked that the chemical study of the phosphates had not attained the same degree of precision as the study of other inorganic substances, and that the mode of proving their presence from their ash was subject to doubt, give directions for crystallizing the phosphates, for which purpose the non-crystallizable substances must be eliminated. When once the phosphatic crystals have been obtained,

it is easy, from their size, to study their form and determine their chemical relation. "When we decant the fluid from highly concentrated urine to separate the saline deposit, and add to it absolute alcohol, crystals of the neutral phosphate of soda are slowly deposited upon the sides of the vessel. These are tables derived from the rectangular, or right rhomboidal prism, with truncation of their edges. Sometimes these tables are irregular, and variously striated upon their surfaces. They polarize light, and the last forms, especially, give colours the most remarkable for their tint and intensity. It is easy, with a little practice, to distinguish these from all other urinary crystals, and, above all, from the acid phosphate."

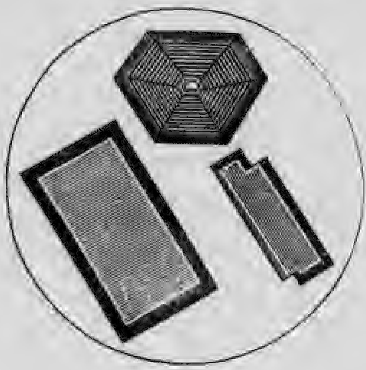

Fig. 55.

In the following chapter they treat of the acid phosphate of soda, (NaO, 12HO, PhO^5, 2HO,) which, as yet, has only been found in the urine. The modes of transformation of the three phosphates are noticed, and the probability that the acidity, alkalinity, or neutrality of

urine may be due to the presence of one of them. They give the following directions for its preparation.

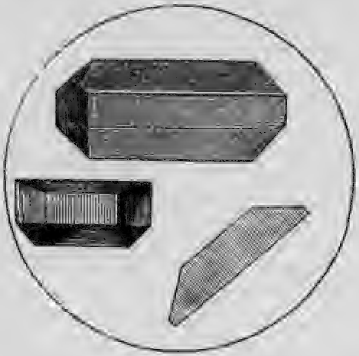

Fig. 56.

Acid phosphate of soda.—" *Extraction.*—This salt may be obtained crystallized in the urine by following the same method as indicated in the treatment of the neutral phosphate of soda. Three or four days after the crystallization of this latter salt, there are deposited crystals which are much more soluble in water; and their deposition may be hastened by adding ether to the liquor already treated with absolute alcohol. These crystals, from the mode of truncation of their angles, or the sides of the base, appear to be derived from the rectangular, or right rhomboidal prism. The truncation usually makes almost the whole of the base. The forms of these crystals vary but little, they are either prisms or tables. They are very transparent, and their faces can only be well discovered as they turn upon themselves under the microscope. They generally adhere to the side of the vessel, and are rarely well formed. They are flattened and incompletely formed on

the side adhering to the vessel." (Robin and Verdeil, ii, 340).*

* The accompanying plate (fig. 57), represents the long, slender crystals of the phosphate of magnesia, observed in the urine of a man who was taking

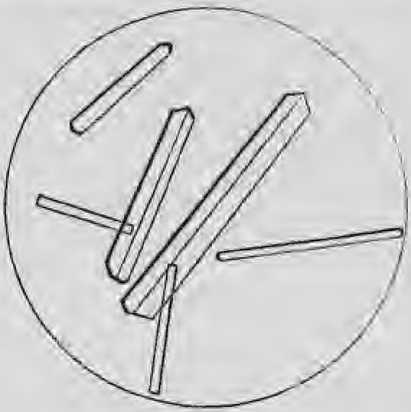

Fig. 57.

the hyposulphite of soda for sarcinæ ventriculi. The urine was clear, alkaline, turning turmeric paper brown, and contained the crystals in large quantities. They were very similar to those mentioned by Dr. Hassall in the 'Lancet.'* In Dr. Hassall's case the patient was also the subject of sarcinæ ventriculi, and was treated by the hyposulphite, but I do not know whether he was taking it at the time when the urine was examined. "In this case, the deposit of earthy phosphates, usually so abundant in the night excretion, examined by the microscope, was found in one sample to consist chiefly of a great number of long and slender crystals, stretching right across the field of vision, pointed at either extremity, frequently split or divided into smaller secondary crystals, and more or less aggregated into bundles. The deposit procured from another sample consisted principally of the same crystals, although they were very much larger, and of somewhat a different shape. Their form, as nearly as could be ascertained, was that of a six-

* Jan. 29, 1853.

Pathological Indications of the Phosphates.

265. The persistent occurrence of deposits of the earthy phosphates in the urine, must be regarded as of serious importance, always indicating the existence of important functional, and, too frequently, even of organic mischief. One general law appears to govern the pathological development of these deposits, viz., that they always exist simultaneously with a depressed state of nervous energy, often general, rarely more local, in its seat. Of the former, the result of wear and tear of body and mind in old people, and of the latter the effects of local injury to the spine, will serve as examples. It is true, that in the majority of these cases there is much irritability present, there is often an excited pulse, a tongue white on the surface and red at the margin and tip, with a dry, often imperspirable, occasionally hot skin. Still it is irritability with depression, a kind of erythism of the nervous system, if the expression be permitted, like that observed after considerable losses of blood. The pathological state of the system accom-

sided prism, the extremities being usually pointed, and furnished with two unequal facettes, not unfrequently the ends were truncated, and occasionally oblique. The deposit was examined chemically more than once, both by Dr. Hassall and Dr. Letheby, and was found to consist chiefly of phosphate of magnesia with some ammonia, and a little phosphate of lime; the latter substances being present as impurities, and forming, in all probability, no part in the composition of the crystals." * At the time I first noticed these crystals, I was not aware of Dr. Hassall's observations; but on referring to different sources to see whether the subject had been previously brought forward, I found the above, which I have much pleasure, as well from the interest I myself take in the subject, the causes being so similar, as in justice to the original observer, to transfer to these pages.

* Ranking's 'Abstract,' vol. xvii, p. 81.

panying the appearance of deposits of phosphate of lime are analogous to those occurring with the triple salt; indeed, as has been already observed (263), they often, and in alkaline urine always, occur simultaneously. So far as my own experience has extended, when the deposit has consisted chiefly of the calcareous salt, the patients have appeared to present more marked evidence of exhaustion, and of the previous existence of some drain on the nervous system, than when the triple salt alone existed: unless its source is strictly local (284).

266. *When the triple salt occurs in small quantities, nearly or entirely free from phosphate of lime* (the urine being acidulous or neutral at the moment of emission, and not restoring the colour of reddened litmus paper until some time after,) we have the simplest cases, or those in which the amount of organic or functional lesion is at a minimum. These patients are generally regarded as labouring under severe dyspepsia. The most prominent symptoms they present, are great irritability of temper, extreme restlessness, mal-performance of the digestive functions, with such imperfect assimilation of the ingesta, that a certain and often extreme amount of emaciation is a constant attendant. The appetite is uncertain, occasionally being voracious; vomiting, or at least irritability of stomach, frequent; fatigue is induced by the slightest exercise; there is a remarkable inaptitude to any mental or bodily exertion, and the patient is often, from the exhaustion thus produced, unfitted for his ordinary duties. In severe cases these symptoms become aggravated by an excessive elimination of urea, which aids considerably in depressing the patient's strength. The urine is generally of a rich amber colour, generally depositing phosphates on the application of heat, and of high specific

gravity 1·025—1·030. Where the presence of triple phosphate is only occasional, its connection may be traced to some cause which has rendered the system morbidly irritable, at the same time that its tone or vigour has become depressed. The simplest examples of this kind that have occurred to me, have been in the cases of individuals of nervous temperament, who have periodical duties to perform requiring extreme mental tension and bodily exertion. I have witnessed this state of things several times in clergymen, especially in those who, from the nature of some secular engagements, have been compelled to lead sedentary lives during the week, and to perform full duties on Sundays. The best illustration of this I ever met with was in the person of a well-known and deservedly popular clergyman, who, from his connection with a public school, scarcely used any exercise during the week, whilst on Sunday he performed duty thrice in his church. This gentleman was a tall, thin person, of dark complexion, lustrous eyes, and almost phthisical aspect. He was the subject of constant dyspepsia. The urine passed on Saturday evening, as well as on Sunday morning, although repeatedly examined, was healthy, except in depositing urates, and being of high specific gravity. Before his Sunday duties were completed, he almost invariably became the subject of extreme fatigue, with a painful aching sensation across the loins, in addition to the flatulence and epigastric uneasiness under which he always laboured. The urine voided before retiring to rest, after the severe exertions of the day, was almost constantly of a deep amber hue, high specific gravity, and deposited the triple phosphate in abundance. The urine of Monday would contain less of this salt, which generally disappeared on the following day, and once more

reappeared on the following Sunday evening. I had an opportunity of observing this state of things for several weeks, and it ultimately disappeared by the patient relaxing from his duties and enjoying the amusement of travelling for a few weeks.

267. Another most severe case of this disease was lately under my care in the person of a West Indian proprietor with a naturally highly susceptible nervous system, rendered still more so by the refinements of education. He had suffered sad reverses, and become the subject of the train of symptoms just described; his irritability was most distressing, and rendered more intolerable by the severe efforts he made to restrain it. He had a hot dry skin, a quick and irritable pulse, mind much depressed, and, in spite of a large share of good sense, was always under the influence of apprehension of some impending peril. The urine was always acid, and remained so for a day after emission, even in hot weather, its specific gravity was 1·028, by heat it became opaque from the deposition of phosphate of lime, and soon after passing, even before it was perfectly cold, a copious deposit of prismatic crystals of the triple phosphate appeared. I have seen an ounce bottle of his urine let fall a deposit reaching to one tenth of the height of the fluid. This deposit lessened rapidly on the partial alleviation of the mental depression and anxiety of the patient, almost without medicine.

268. In mild cases of indigestion, especially in gouty dyspepsia, it is not uncommon to find the iridescent pellicle of triple salt, the urine being rich in urea. This condition must be regarded as an attempt made to get rid of an excess of a salt derived either directly from the food, or by a freer disorganization of tissues by secondary assimilation, than exists in health. This pe-

culiar state of the urine is characterised, it must be recollected, as well by its being acid, or at least neutral, and rich in urea, as by the phosphatic pellicle. This is an important distinction between the urine in question and that secreted by many persons after breakfast, where fluids have been freely drank, and bread rather copiously partaken of. In many persons, even in good health, the urine voided shortly after breakfast is alkaline, pale, soon becoming covered with a pellicle of phosphates, but of low specific gravity, and containing but a small quantity of animal matter. I have repeatedly observed the occurrence of this phosphatic urine, rich in urea, in the dyspepsia attended with a sense of weight and tightness after food, with flatulent distension of the stomach so frequent in women at the period of their great climacteric. This state does not generally terminate in decided gravel or the formation of a stone; it is rather to be regarded as an index of the state of the assimilative functions than as leading to the ulterior deposit of calculous matter. The most valuable diagnostic mark of these cases, in contradistinction to those where organic mischief is to be apprehended, is founded on the fact that the phosphates are chiefly confined to the urine passed at night. The following table gives the result of some observations on this kind of urine.

URINE DEPOSITING PHOSPHATES INDEPENDENTLY OF ORGANIC DISEASE.

Evening urine.				Morning urine.				Case.
Colour.	Density.	Action on litmus.	Deposit.	Colour.	Density.	Action on litmus.	Deposit.	
Pale amber.	1·029	Neutral.	Prisms of triple phosphates.	Dark amber.	1·031	Neutral.	Red urates.	Gouty dyspepsia.
Normal.	1·028	Alkaline.	Ditto.	Normal.	1·025	Acid.	Urates.	Ditto.
Pale.	1·020	Neutral.	Ditto with phosphate of lime.	Pale.	1·025	Acid.	Uric acid.	Ditto.
Pale.	1·022	Neutral.	Nearly all phosphate of lime.	Normal.	1·025	Acid.	Uric acid.	Ditto.
Normal.	1·028	Barely alkaline.	Prisms and stellæ of phosphates.	Normal.	1·031	Neutral.	Uric acid and scanty prisms of phosphate.	Dyspepsia of intemperance.
Amber.	1·025	Acid.	Prisms of phosphate.	Normal.	1·020	Acid.	None.	Dyspepsia following fatigue.
Amber.	1·025	Acid.	Fine stellæ of triple salt.	Normal.	1·020	Acid.	None.	Dysmenorrhœa.
Normal.	1·030	Acid.	Do. abundant.	Amber.	1·025	Acid.	None.	Dyspepsia & nervous excitement.

269. Deposits of the triple salt frequently occur in very old people, in whom the state of decrepitude depending on senility has either become extreme, or been aggravated by low living and a want of the ordinary comforts of life. In several cases of this kind occurring in octogenarian dependents on parochial relief, the urine has been very pale, of low specific gravity (1·008—1·0012), subacid or neutral, and extremely fœtid. This fœtor, not unlike that of stale fish, did not appear to depend so much upon the presence of free ammonia, as from the occurrence of a slow decomposition of the organic constituents of the urine.

270. Crystals of triple phosphate have been observed by Professor Schönlein and Dr. Simon in the urine of persons convalescing from pleurisy and pneumonia. I have met with them very generally in the slightly acid urine of patients who were just emerging from an attack of acute disease, especially of rheumatic fever. During one summer the urine of all the patients under my care at Guy's Hospital was almost daily examined by two of my then most indefatigable and intelligent pupils, Dr. R. Finch and Dr. H. F. Johnson, acting at that time as clinical reporters. The results of their investigation was the discovery of the fact above stated. In these cases, also, the presence of the salt must be regarded as indicative of irritability with exhaustion, and it disappears spontaneously on the recovery of health and vigour.

271. It has been frequently stated, that in the course of continued fever, the urine at a certain period becomes alkaline, and deposits phosphates. It is well known that early in fever the urine is high-coloured, acid, and loaded with uric acid or urates (140); and it is distinctly stated by Dr. Simon,[72] from observations

made under the sanction of Professor Schönlein, of Berlin, that the acidity vanishes, and is replaced by an alkaline state, at a period of the disease varying with the powers of the patient, but generally about the end of the second week. Simon states that in cases of severe typhoid fever, in which the urine is acid and deep-coloured, it, just at the period when comatose symptoms set in, becomes alkaline and pale. On examination he found carbonate of ammonia in solution, resulting, of course, from the re-arrangement of the element of urea (77). That this alteration of acid to alkaline urine may and does occasionally occur in the course of a case of fever, is certain, but that it is the general rule, as assumed by Schönlein and Simon, is certainly opposed to all the experience I have had in the disease in question. M. Becquerel[73] has made a similar remark, and adds, that out of thirty-eight cases of typhus, where urine was constantly examined, he found it alkaline in one case only, and in this pus was present. Dr. Graves,[74] of Dublin, some time ago drew attention to the fact that the urine in fever was occasionally ammoniacal, and deposited the earthy phosphates; in the two cases related by him extreme exhaustion existed, in one anasarca, and in the other petechiæ accompanied the fever. In the epidemic of maculated fever, which occurred in London some years ago, I often found the urine alkaline in the second week; but this appeared to me almost peculiar to that epidemic. On submitting the urine to analysis, a marked deficiency, and after a time, a total absence, of urea was detected. Hence it appeared, that owing to the state of enervation which existed, the kidneys in separating C_2, N_2, H_6, O_4, from the blood, instead of excreting these elements, as C_2, N_2, H_4, O_2 = urea and

$2 H O$ = water, allowed them to become obedient to ordinary chemical laws, and they then arranged themselves into $2 C O_2 + 2 N H_3$ = two atoms of carbonate of ammonia. In all cases in which alkaline urine occurs care must be taken to ascertain the possibility of its having been produced by the ingestion of salts of the vegetable acids, or by subacid fruits, as Prof. Wöhler[131] has shown that a meal of apples or baked plums soon renders the secretion alkaline (163).

272. The researches of Drs. Sutherland and Rigby[135] on the urine of insane patients, appear to authorise the assumption, that cerebral lesion, independent of any obvious implications of spinal mischief, may induce the conversion of urea into carbonate of ammonia. They found the urine capable of effervescing on the addition of *acetic acid* in 34 per cent. of cases of dementia, 30 per cent. of melancholy, and 16 per cent. of mania.

273. When the deposit is copious, either readily falling to the bottom of the vessel, or remaining suspended in the urine like mucus, the two phosphates are generally found mixed. In these cases an alkaline condition of the urine almost invariably occurs, a piece of turmeric paper being readily stained brown on being immersed in it. The odour also is very disagreeable, and is generally said to be ammoniacal, although in very many instances the term fœtid would be more appropriate, as ammonia is by no means necessarily evolved. This kind of urine, if not depending upon organic disease of the urinary apparatus, is always connected with some serious affection of the spinal marrow. In a mild form this is observed after slight violence inflicted on the spine or over the region of the kidneys, and generally disappears in a few days. I have seen a copious deposit of phosphates with alkaline urine occur for a few days

in the case of a young gentleman who had exerted himself too much in a riding school. The fact of alkaline urine resulting from strains or blows on the back was first noticed by Dr. Prout,[68] and injuries to the loins have been long enumerated among the existing causes of renal calculi. This alkaline state of the urine and deposition of phosphates, is a pretty constant result of anything which depresses the nervous energy of the spinal marrow, whether the result of insidious disease of the spine, or the effect of sudden mechanical violence. Further, as observed by Sir B. Brodie, this condition of the urine, whenever it follows spinal injuries, appears not to be connected with the particular locality of the injury, but to occur equally in accidents to the lumbar, dorsal, or cervical regions.

274. It is well known that all the hollow organs of the body are endued with a sufficient amount of nervous energy, or vital power, to preserve the fluids they contain from change for a long time. Thus the blood in an artery, even when its motion is prevented by ligature, does not change in a space of time sufficient to convert it, if removed from the vessel, into a putrescent mass. The bile in the gall-bladder, the urine in the kidneys and bladder, the fæces in the intestines, are examples of the same fact. This law even obtains in disease; for a serous or purulent effusion, the result of morbid action, will be preserved in the living cavities of the body unchanged, while a few hours would be sufficient to render it fœtid and putrid, if exposed, out of the body, to the influence of a similar temperature. It is, therefore, evident that in so complex a fluid as the urine, the vital endowments of the living cavities containing it, alone preserves it from undergoing the change which so readily occurs out of the body. The power

thus possessed by the bladder of preserving its contents unchanged is indisputably dependent upon the integrity of the spinal nerves, and branches from the organic system supplying it. If, therefore, any injury even of an indirect character, be inflicted upon them, the result must of necessity be the diminution to a certain extent of the vital power of the organ, and the fluid it contains will become susceptible of changes analogous to those which occur in it when removed from the body. One of these changes is the union of the urea with the elements of water, and the formation of the carbonate of ammonia (77). The base of this salt, by uniting with the normal acid of the urine, will precipitate the earthy phosphates with some carbonate of lime; the latter being the result of the decomposing influence of the carbonate of ammonia on the phosphate of lime. Whether the decomposition of urea be the primary chemical change, or is the result of some antecedent one, is unknown. Professor Dumas[118] has ingeniously suggested that the vesical mucus may undergo a putrescent change; and this, acting as a ferment, may induce the metamorphosis of urea into carbonate of ammonia, just as yeast aids the conversion of sugar into alcohol.

275. The urine thus rendered ammoniacal, acts as an irritant on the mucous membrane of the bladder, exciting a form of inflammatory action; and the result of this is the secretion of a large quantity of mucus of a more viscid character than usual. By persistence of the irritation, puriform mucus is at length poured out, and this, from the chemical influence of the carbonate of ammonia, becomes changed into a viscid, almost gelatinous mass; sometimes so tenacious as to form long viscid tough ropes of mucus, capable of being drawn out to the length of several inches without breaking. The

formation of this matter greatly adds to the patient's sufferings by preventing the ready escape of the urine even when the contractile power of the bladder is not quite paralysed. I thus regard the depressed vitality of the bladder to be the initiative in these series of changes, the next step is the decomposition of the urine and formation of carbonate of ammonia which acts as the exciting cause of the excessive secretion of unhealthy mucus, the urine being supposed to be acid at the time of secretion by the kidneys. In the case of a woman in Guy's Hospital, labouring under complete paraplegia, and passing, with the aid of a catheter, fetid, alkaline, and phosphatic urine, I washed out the bladder with warm water, and allowing the secretion of urine to go on for half an hour, the catheter was again introduced, and an ounce of pale acid urine escaped; proving that the alkaline condition of the urine previously removed was owing to the changes it underwent subsequent to secretion.

276. A somewhat different view of the cause of alkaline urine has been published by Mr. Blizard Curling;[71] this gentleman believes that the immediate result of spinal lesion, is the loss of the natural sensibility of the bladder; the effect of this is the secretion of unhealthy alkalescent mucus, which acting chemically upon the urine, renders it alkaline, and leads to the deposition of the earthy phosphates. Subsequently the urine may be actually secreted in an alkaline state by the extension of irritation from the bladder to the kidneys, or by the latter sympathising with the debilitated yet irritable state of the system.

The opinion that alkaline urine may eventually be secreted by an extension of irritation to the kidney, receives considerable support from an interesting case which occurred some time ago in Guy's Hospital. A

man was admitted under the care of my colleague, Mr. Bransby Cooper, for injury to the spine, resulting from accident. He was paraplegic; the urine soon became alkaline, and he died. On a post-mortem examination, the contents of the bladder restored the colour of reddened litmus paper, and on making a section of the kidneys, the papillæ were found incrusted with prismatic crystals of the triple phosphate.

277. Mr. Curling considers that the mere continuance of urine in the bladder is not sufficient to allow it to become alkaline, but that a diseased condition of the mucous lining is a necessary condition in effecting this change. Hence in enlarged prostate, when the bladder is often distended for a long time, the urine is generally acid, even when only emptied by the catheter twice in the day. But when, on the other hand, a catheter is worn in the bladder, so that no accumulation can take place, the urine is often alkaline; a circumstance admitting only of explanation by the secretion of unhealthy mucus, excited by the irritation of the instrument.*

278. Dr. Snow has made some ingenious experiments on the conditions for the development of alkalescence in the urine whilst in the bladder, and he has produced much evidence to prove that whenever this cannot contract so as to get rid of all its contents, the small quantity thus retained will become alkaline, and be sufficient to induce a similar state in the freshly secreted urine soon after its dropping from the mouth of the ureter

* Dr. Owen Rees' views on this subject are well known. They are clearly enunciated, and supported by some strong facts; I fully concur with him in the benefit of alkaline treatment in those cases in which the alkalinity of the urine is decidedly due to irritation or inflammation of the mucous membrane. His remarks,also,on the use, or rather abuse of the catheter, are most important.

upon it. Newly voided acid urine was kept at a temperature of 100°, dropping from one vessel into another, about the rate at which it enters the bladder. The upper glass vessel used was emptied completely, and washed with water every six or eight hours before putting in fresh urine, but the lower one had always a few drops of the stale urine left in. The result was that the urine in the lower vessel was always alkaline, whilst that in the upper was constantly acid. These researches afford a strong argument in favour of the practice of frequently washing out the bladder, in cases of alkaline urine.

279. The urine may be alkaline, and loaded with phosphates, simply from disease limited to the bladder. In all cases in which disease of the mucous membrane, especially of a chronic character, exists, more particularly where retention of urine occurs, the urine is almost always phosphatic, and abounds in viscid mucus. This is seen in cases of old stricture of the urethra, chronic cystitis, and many of the affections included under the generic term of irritable bladder. I have witnessed more than one instance in which the state of the urine alluded to has resulted, in women, from secretion of unhealthy mucus, by the propagation of irritation from an irritable uterus, or even inflamed vagina. In all these cases the patient's suffering is much increased by the formation of soft pseudo-calculous masses of mucus and phosphates, blocking up the urethra.

280. This condition ought to be regarded as quite distinct from the cases already alluded to, in which the presence of the phosphatic deposit is indicative of, and produced by, great irritability and depression, or spinal lesion. It is hence very important to be able to diagnose correctly between cases of alkaline urine depending upon

causes strictly local (*i. e.* bladder affection), and those of a more general character. Dr. B. Jones[139] has suggested for this purpose the action on litmus paper, as it would appear that urine is alkaline from ammonia when the cause is local, and from a fixed alkali when the ailment is more general. He has certainly succeeded in establishing the fact that urine may be frequently alkaline and not ammoniacal, although of course when ammoniacal it is always alkaline. The urine which, as already stated, is sometimes alkaline after breakfast, generally owes this to a fixed alkaline carbonate being present. In such urine a piece of red litmus paper is always turned blue, and remains so after being dried even by artificial heat. Whereas, if the urine is alkaline from the presence of a carbonate of ammonia, although red litmus paper is rendered blue when immersed in it, yet by drying, especially if held near a fire to warm it, the ammonia evaporates, and the paper resumes its red tint. There is another important distinction between these two forms of alkaline urine. When alkaline from ammonia, abundant crystals of triple phosphate are always found; whilst, when ammonia was absent, Dr. Jones states that these crystals are rarely present, and are replaced by a copious and dense deposit of phosphate of lime.

281. Cases occasionally present themselves in which the urine is very copious, pale, and freely deposits the phosphates, independent of any local disease in the genito-urinary organs, and in which the general symptoms are those of marasmus; the appearance of the patient, and his most prominent ailments, much resembling a case of diabetes. It is in these that the formation of a calculus is more especially to be dreaded; and even if these evils be arrested, the patient too generally goes on from bad to worse, and dies worn out with irritation. An instance

of this kind has been alluded to (267), and I shall have occasion to refer to another when speaking of the treatment (294) of the disease. Even in these, a careful investigation of the case will generally lead to a detection of some antecedent causes of spinal mischief: and in many, abuse of the sexual organs have constituted the most prominent exciting cause. I have seen some in which no other antecedent morbid influence could be discovered than the cachexia produced by the abuse of mercury.

282. The deposits of phosphates, where no organic disease exists, are often absent, not only for hours (266), but for days together; and this fact will often enable us to predict, with tolerable confidence, the happy termination of the case. From all the experience which I have had of phosphatic deposits, I feel confidence in offering the following as a safe induction from clinical observation, and one of great service in practice.

That, where the presence of a deposit of phosphates is independent of the irritation of a calculus, or of organic disease, it is most abundant in the urine passed in the evening (urine of digestion), and absent or replaced by uric acid, or urates, in the morning (urine of the blood), the urine being always of a tolerably natural colour, never below, and often above the mean density. Where the presence of phosphatic salts depends on the irritation of a calculus, or of organic mischief in the urinary passages, the urine is pale and whey-like, of a density below the average, often considerably so, and the earthy deposit is nearly equally abundant in the night and morning urine.

283. I cannot close this part of my subject without drawing attention to the conclusions arrived at by Dr.

B. Jones on the relation borne by phosphatic salts to certain pathological conditions. Their importance is too great to permit them to be overlooked. He has shown: 1. That no determination of an excessive secretion of phosphoric acid can be afforded by the deposit of earthy salts, unless the quantity of lime and magnesia in the food be taken into account. 2. That no *real increase* of phosphatic salts occurs in spinal diseases, notwithstanding the existence of deposits. 3. That in fever, and in most acute inflammation, the phosphatic salts are not increased. 4. That in old cases of mania, melancholy, paralysis of the insane, or in chronic cases of disease in which nervous tissues are uninfluenced, no conclusions can be drawn. 5. In fractures of the skull the phosphatic salts increase only when any inflammatory action occurs in the brain, and in acute phrenitis an excessive increase takes place. 6. In delirium tremens there is a marked deficiency of phosphates unless they are introduced with the ingesta; an excess is, however, met with in some functional affections of the brain.

284. Some curious cases are occasionally met with, in which enormous quantities of phosphate of lime have come away for a long time in the urine without apparently doing much mischief. A very remarkable instance of this kind occurred some years ago among the out-patients of Guy's Hospital, in the person of John Jenkins, an old man under the care of my colleague, Dr. Hughes. This patient was an habitual dyspeptic, and had laboured under pyrosis from boyhood. He had during many years been in the habit of passing almost milky urine, which by repose deposited such an extraordinary quantity of phosphate of lime, that he brought to me at one time more than an ounce of the salt. He had been for this disease under the treatment of half the hospital physicians

and surgeons in London. He had stated, that fifty years previously he had been a patient at Guy's Hospital under Dr. Saunders, and subsequently under Dr. Fordyce at St. Thomas's; but his urine had never at any time exhibited any signs of improvement. Indeed, all the remedies tried appeared quite useless; at the same time, this man's general health was so good that there was scarcely an excuse for submitting him to any course of treatment beyond the apprehension of the possible formation of a calculus. In cases of this kind it is very possible that the phosphate of lime is secreted from the mucous membrane of the bladder, and not derived from the urine. All mucous secretions contain phosphoric acid, combined with earthy bases; and hence, if an excess of the latter is secreted with the vesical mucus, it may be washed away with the urine and form a deposit. This is by no means unfrequent in the irritable bladder, depending on the existence of prostatic diseases, &c.: we have a perfect analogy to this in the calculous concretions found in the ducts of glands furnishing mucous secretions. These are all prone to secrete phosphates in too great an excess to be washed away with the secretion; they are therefore retained, and form a calculus. These, from whatever part of the body they are obtained, present nearly the same composition.

Composition of Phosphatic Concretions.

Species.	Prostatic.	Seminal.	Salivary (horse.)	Salivary (human.)	Pancreatic.
Phosphate of lime	84·5	90·	3·	75·	80·
Carbonate of lime	·5	2·	84·	2·	3·
Animal matter and water ...	15·0	10·	12·	23·	7·
Authority...........	Laissaigne	Peschier	Lassaigne	G. B.	G. B.

285. *Therapeutical indications.*—In considering the indications for treatment in cases where the phosphates appear in the urine in the form of deposits, whether their quantity be in excess or not, it will be necessary to regard practically at least four pathological conditions, the existence of one or other of which must be deduced from the symptoms presented by the patient.

A. Cases in which dyspepsia, often to an aggravated extent, with some febrile and nervous irritation, exists independently of any evidence of antecedent injury to the spine (266).

B. Cases characterised by high nervous irritability, with a varying amount of marasmus, following a blow or other violence inflicted on the spine, but without paralysis (273).

C. Cases in which the phosphatic urine co-exists with paraplegia, the results of spinal lesion (275).

D. Cases of diseased mucous membrane of the bladder (279).

Of these it will be only necessary to direct attention to the first, second, and fourth series of cases, as the third includes cases in which the deposition of phosphates constitutes a mere symptom of a grave and serious lesion, which, whether the result of accidental violence or insidious disease, must be treated according to the particular disease existing.

Phosphatic deposits connected with Irritative Dyspepsia.

286. Examples of this class of cases, or those in which a particular form of irritative dyspepsia is the character-

istic feature, are by no means uncommon. Every now and then patients present themselves, in whom the most prominent symptoms are a capricious appetite, sense of weight and fulness at the præcordia, especially after meals, irregular bowels, severe lancinating pains darting between the scapulæ from the pit of the stomach; much flatulence, tongue white, often with injected marginal papillæ, sometimes morbidly red over its whole surface; pulse quick and irritable, dull heavy aching pain across the loins, excessive depression of spirits, despondency so intense as often to excite the most painful ideas. In a merchant, surrounded by affluence, apprehensions of impending beggary often embitter the moments that are free from the excitement of business; in the mechanic, unfounded ideas of immediate loss of employment, and visions of the interior of a workhouse, are generally present. On examining the urine its specific gravity is often above the average; the deposition of crystalline or amorphous phosphates, and often excess of urea, will refer the case to its proper class, as one of irritative dyspepsia, in which the excess of phosphates indicates the "drain" on the nervous energies.

287. The treatment of these cases must be rather directed by general principles, than limited to effecting the mere solution of phosphatic deposits. It is true that by the persistent administration of acids the deposit may disappear for a time, but the ailment goes on; all that is effected by such treatment is to mask a symptom, and an important one, of the progress of the malady. After having attended to the morale of the case, as far as possible removing from the patient any morbid influence existing in his mind, whether real or imaginary, the next thing is to attend to the general health. The bowels should be freed from any unhealthy accumulation

by a mild mercurial laxative, as a few grains of pil. hydrarg., followed by a dose of rhubarb or castor oil; but all active purging should be avoided, as it generally aggravates the distress of the patient, and decidedly interferes with the success of the treatment. A combination of a tonic-laxative with a sedative may then be administered, as tinct. hyoscyami et sp. ammon. aromatici, aa, ♏xx—ʒss, ex. mist. gentianæ, co., ℥j, ter in die. If the bowels be irritable, the inf. cascarillæ, or inf. serpentariæ, may be substituted for the mist. gentianæ, comp. Should gastrodynia exist, great relief will be obtained by the administration of half a grain of oxide of silver, made into a pill with confection of opium, before a meal. The diet should be very carefully regulated, all bland nutritious articles of food being preferred; vegetables should be avoided, and, in general a small quantity of good sherry may be allowed. By a plan of treatment of this kind, the patients generally do well, and the phosphates and excess of urea vanish from the urine. As the patient approaches convalescence, much good is often effected by the use of sulphate of zinc in gradually increasing doses, beginning with a grain thrice a day, made into a pill with a little ext. hyoscyami, or ext. gentianæ, and increasing the quantity every three or four days, until five grains or more are taken at a dose. Under the use of the zinc, I have seen many cases do well, in which the irritable state of the nervous system, and accompanying mental excitement, almost approached in severity and character that observed in delirium tremens. I need hardly say that change of scene and occupation are important adjuvants to our medical treatment.

288. Much less frequently these cases will become chronic, the secretion of phosphates being continued for years, and the irritability of stomach being so severe and

persistent as to lead to the emaciation of the patient and presence of all the symptoms of scirrhous pylorus. These cases are sometimes relieved by the administration of strychnia. This drug has a remarkable influence over a simply irritable stomach, and is indeed superior to any other anti-emetic remedy, providing there be no acute or inflammatory action in the affected organ; and under its use I have seen the urine assume a remarkably healthy character. It may, indeed, be hazarded as a probable opinion, that strychnia may prevent the decomposition of urine in the bladder and consequent deposition of earthy salts from its influence on the spinal nerves. The following case is a remarkable illustration of the foregoing remarks. It is abridged from the account of Dr. Robert Finch, who reported it:—

Irritative dyspepsia simulating scirrhous pylorus, with copious secretion of triple phosphates.

G—— L——, æt. 18, admitted into Luke's Ward, under Dr. Golding Bird, April 9, 1845, a native of Bristol, and employed at an iron-factory; had always lived temperately, and his health, previous to the present illness, had been good, being merely the subject of occasional attacks of indigestion, with flatulent eructations. Four years before, vomiting had come on suddenly, after ordinary meal, accompanied by severe pains at the pit of the stomach, to which, in a less severe form, he had been subject during the previous year. With occasional, but rare intermissions, this vomiting recurred daily after every meal for six months, being preceded by intense pain, relieved on emptying the stomach. It became less frequent for the following eight months, occurring but once or twice a day, but never losing it for twenty-four hours at a time. He then became a patient at the Bristol Infirmary, and underwent a great variety of treatment, with the general result of obtaining partial relief, but never losing his daily paroxysms of pain and vomiting.

On admission into Guy's Hospital, the lad's complexion was pale and bloodless, with a slight icteric tint; emaciation most extreme, his bones were

barely covered, and his face was so extraordinarily emaciated, that it rather resembled a skull, over which parchment had been drawn, than anything else. His general appearance was that of a person in the last stage of scirrhous pylorus. He complained of burning heat at the scrobiculus cordis, and heavy pain across the loins; tongue clear and red; pulse quick and sharp; skin dry and imperspirable. He always vomited a short time after every meal, and declared that he had not passed a single day during four years without being sick three or four times. There was great thirst; bowels acted daily, with frequent eructations possessing an odour of stale fish. Urine loaded with triple phosphate, and alkaline, with a disgusting fishy odour, even when first passed, sp. gr. 1·020, not albuminous. No tumour could be felt at the scrobiculus cordis, where there was some tenderness on pressure; the abdomen distended with flatus.

April 9th.—Vomited nearly four pints of thin acid yeast-like matter.

Misturæ Magnesiæ, ℥j, ter in die.
Milk diet.

11th.—Vomited daily after dinner. The vomited matter presented the same yeast-like appearance. Urine had an ammoniacal odour, and deposited phosphates copiously.

℞ Strychniæ, gr. j.
Acidi Nitric dil., ʒj.
Aquæ, ℥xij.—Solve et capiat æger, ℥j, ter in die.

He was strictly confined to milk diet; the medicine to be taken fifteen minutes before each meal.

14th.—Vomited yesterday before dinner, and again after tea, and after breakfast this morning.—P.

15th.—Vomited last night, but not since; has passed 30 ounces of urine in the preceding twenty-four hours, copiously depositing phosphates; appetite good; begged for a continuance of the medicine, stating that it kept his food down; abdomen not so flatulent.

16th.—In no pain; vomited last night at seven o'clock, with rather more than usual pain; urine alkaline; 40 ounces in twenty-four hours, and full of prismatic triple phosphates.

℞ Olei Tiglii, ʒj.
Lin. Saponis, ʒvij. M. ft. Linimentum scrobiculo cordis bis die illinendum et Pergat.
Fish diet.

19th.—Not vomited since the morning of the 17th; the liniment brought out a crop of pustules; felt no pain since the vomiting ceased; urine neutral, containing but little deposit; complained of great thirst.—P.

22d.—For the last two nights his skin has acted freely; urine free from deposit, sp. gr. 1·014; troublesome flatulent eructations.—P.

From this report, the same treatment being continued, the patient improved, the vomiting ceased, and the urine became acid. He had recovered his good looks, and became decidedly fat in his face. On May 19th, he suffered a slight relapse after paroxysms of pain in the region of the left kidney, followed by vomiting and the discharge of urine loaded with phosphates, and becoming alkaline soon after emission. This was but a transient attack; he soon recovered, and left the hospital apparently quite well.

May 31st.—This patient appeared among the out-patients apparently pretty well; he had suffered one relapse since leaving the hospital after a copious meal of tripe. The urine was, however, not quite healthy, and contained some phosphates.

289. Sometimes, although rarely, the phosphates will disappear from the urine, and be replaced by the oxalate of lime; a change that should excite serious apprehensions for the patient's ultimate welfare. This generally occurs in persons who by imprudence have drawn some time previously a heavy bill upon their health. The following is one of the few cases of this kind I have witnessed.

Irritable bladder following repeated gonorrhœa; dyspepsia; severe lumbar pain; triple phosphates followed by crystals of oxalate of lime.

I was requested by my friend, Mr. Complin, of Charterhouse Square, to see a patient in whom he suspected the presence of renal disease. He was a fine, florid person, æt. 25, who, from his own confession, had been most irregular in his habits; he owned to having laboured under twenty-five different attacks of gonorrhœa. Eight years ago he had cystitis, following the injection of some fluid into the urethra for the cure of gonorrhœa; he at the same time drinking a bottle of port daily. During this attack he passed a large quantity of bloody mucus, which continued pretty constantly for five months; nor did it entirely cease for fifteen months. He was then treated by Dr. Budd, of Plymouth.

He spent the year 1837, and part of the succeeding one, in yachting to the West Indies and Southern Africa. He then returned to England, and got married. His habits became more regular, occasionally only indulging in wine. His appetite, however, continued to be, as it ever was, most voracious, often eating, as he at least declared, three pounds of meat and bread for dinner.

In January, 1842, he fancied he had some obstruction in the urethra, and passed a bougie; this produced much irritation, and was followed by intense pain over the left kidney, darting to the sacro-sciatic notch; this continued up to the time I saw him (April the 23d,) occasionally only being absent for a day or two, always being reproduced after partaking of a hearty or indigestible meal. Walking did not appear to increase the pain; on the contrary, although its severity often crippled him, yet if he could succeed in walking a few yards, he was generally relieved.

When the severe pain was absent, there was always a considerable amount of tenderness on pressure over the left kidney. To add to his annoyances, he suffered considerably from irritability of the sexual organs, attributed to his rarely being able to indulge in sexual intercourse, in consequence of his wife suffering from profuse menorrhagia.

April 23d.—The urine passed last evening was faintly alkaline, of specific gravity 1·028, of natural colour, and appeared to contain a dense mucous deposit, which, under the microscope, was found to consist of large prisms of triple phosphate, mixed with stellæ, formed by a number of finer prisms cohering together. By repose an iridescent film of crystals of the triple salt formed on the surface of the urine; and on the application of heat, an amorphous deposit of the phosphate of lime fell. On the addition of acetic acid to the turbid urine under the microscope, the whole deposit dissolved, the prisms vanishing much more rapidly than the stellæ.

24th.—The urine passed this morning was neutral, of a deep amber colour; its specific gravity was 1·031; it contained a mucous cloud, entangling a few prisms; on the application of heat a thick deposit of phosphate fell. A large excess of urea was present; the addition of nitric acid producing a rapid growth of crystals of the nitrate of urea in a few seconds.

25th.—His symptoms continued the same. The urine was again examined; that passed last night was acid, of a deep amber colour, and of a density of 1·030; it contained merely a delicate mucous cloud in suspension, there being no distinct deposit; on the application of heat, a deposit of phosphates, soluble in acetic acid, occurred. A large excess of urea was present. On placing a drop of the urine under the microscope, it was found abundantly loaded with very large octohedral crystals of oxalate of lime, unmixed with phosphates or urates.

26th.—The urine passed this morning much resembled the night specimens, save that it was quite free from oxalate; its specific gravity was 1·030, and was loaded with urea; it did not become turbid by heat.

May 2d.—I again saw my patient; up to this time he had taken no medicine, except a brisk purgative, as I was anxious to watch the urine. He now stated that since its action the lumbar pain had become much diminished. He boasted to me that two evenings previous he had drank a bottle and a half of port at dinner, and felt better for it. He begged to be allowed to avoid physic, unless he became worse; and it was with some difficulty that I procured a specimen of urine.

3d.—The urine passed last evening was acid, of deep amber, specific gravity 1·030, contained no visible deposit, but the microscope detected an abundant deposit of octohedral crystals of oxalate of lime diffused through it; it deposited phosphates by heat, and contained a large excess of urea.

4th.—The urine passed this morning resembled the last-described specimen; both were remarkable for the oily appearance they presented when poured from one vessel to another—a circumstance probably depending upon the great excess of urea they contained.

Phosphatic deposits connected with functional (?) spinal lesions.

290. Cases of the second class, characterised by a much higher amount of nervous irritability, and of a rapidly progressing emaciation, traceable to some shock to the spine, are not so frequent as those just alluded to, and are far less amenable to treatment.

In these, the phosphatic deposit is often copious, and sometimes consists nearly exclusively of phosphate of lime; the lumbar pain and weight are considerable, the skin often dry and scarcely perspirable; in some cases, indeed, I have seen it look as if varnished; the tongue sometimes white, is often red; the thirst often great; indeed, the general appearance of the case closely resembles one of diabetes. The urine is generally more

copious than natural, almost always pale, and of a specific gravity below the average. On investigating the patient's history, some evidence of a previous strain or wrench of the back, or a blow over the spine, is always elicited. These patients are seldom hypochondriacal; but intense irritability of temper, and a painfully anxious expression of countenance and manner, are almost invariably present.

291. In the treatment of these cases it is important to bear in mind the fact, that although the first exciting cause of the malady is to be found in some shock to the spinal cord, involving the integrity of function of some of its nerves, more especially of those which are connected with the great sympathetic (and supply the whole of the chylo-poietic viscera), yet the irritation has become reflected to the brain, and hence the excitability and the depressed health such cases always present. The great end and aim must be to subdue the morbidly irritable state of the brain and nervous system; to remove any cause, if such exist, interfering with the healthy state of the spinal structure; and subsequently, by a generous diet and persistent use of those tonics which appear especially to exert their influence on the organic nerves, as silver, bismuth, zinc, &c., to endeavour to restore the assimilative functions to their due vigour. Besides the general indications to be fulfilled by regulated diet, amusements, exercise, &c., the use of narcotics, especially of opium, or the preparations of morphia, should be regarded as of the highest value; and we are indebted to Dr. Prout for first directing the attention of the profession to their use.

292. The case of this affection recorded by Dr. Prout[75] was one of peculiar severity, and I have had but few cases before me in practice which at all equalled it. I can, however, add my testimony to the efficacy of narcotics

in the cases I have seen. Morphia appears to me to be somewhat preferable to crude opium, and under the persistent use for several weeks of one third or even one half a grain of the acetate, three or four times in the twenty-four hours, the deposit has vanished from the urine, and the patient done well. In these, as in the preceding class of cases, the shower-bath, and cold douche over the loins, followed by friction with horse-hair gloves, have been of essential service. To succeed in the cases, the treatment must be persistent, for they are essentially chronic in their character; and if remedies be intermitted too soon, may end in fatal marasmus, and in some, the formation of a calculus.

293. Cases occasionally occur in which the symptoms are of a much milder character, but which insidiously go on to the formation of a calculus. It is in these in particular that the use of acids is called for, to hold the phosphatic salts in solution, and prevent their being moulded into a concretion in the pelvis of a kidney. Unfortunately there is a great uncertainty attending their use; indeed, I felt almost inclined to question whether any of the mineral acids, except the phosphoric, really do reach the urine, and thus destroy its alkaline character; certainly, in the majority of cases, even their continued employment appears to be utterly ineffectual in rendering the urine acid. Dr. B. Jones has shown, that the continued administration of dilute sulphuric acid in doses far above those ordinarily employed, or indeed safely administered, in medicine, hardly added in the slightest degree to the acidity of the urine. So far as I have watched cases of this kind, the nitric acid seems to produce the smallest amount of gastric derangement, and appears sometimes to render the urine acid, or at least diminish its alkaline reaction. Although I do not feel inclined to

believe that the acid itself really reaches the urine, and acts as a solvent for the deposit, I am disposed to explain its influence by a reference to its tonic and alterative action, so that when it acts at all, it does so by improving the general health. From some late observations, it appears probable that bodies which coagulate albumen are by no means readily if ever absorbed, and cannot consequently be discovered in the urine; thus gallic acid, which scarcely acts on albumen, is absorbed, and soon reaches the urine;[139] while its close ally, tannin or tannic acid (324), readily coagulates albumen, and I believe has not been discovered in the urine after its administration. Is it possible, by this view, to explain the fact recorded in the first edition of this work, that phosphoric acid had appeared in many cases to lessen the alkalescence of the urine when other acids were useless? Mr. Ure[76] has recommended the employment of benzoic acid, under the idea of its destroying the alkaline state of the urine in consequence of its metamorphosis into hippuric acid; and he has recorded the history of a case thus treated. I confess that in my hands this drug has not been very successful, and when it is recollected that hippuric acid requires about four hundred parts of water for solution, and that it reaches the urine combined with ammonia (168), and not in a free state, we can, I think, hardly place much confidence in it as a solvent for the earthy phosphates.*

294. The following case will illustrate the general progress of an excess of phosphates, ending in the formation of a calculus:—

* The acidity of the urine may, in certain morbid states, be referred to the presence of hippuric or lactic acid.

Phosphatic urine and formation of calculi, following injury to the kidney; gradually increasing diuresis; persistence of the deposit of phosphates.

George W—, æt. 39, came under my care February 24th, 1843; he had been engaged at the distillery of Messrs. Booth during the preceding five years, during which period he had partaken pretty freely of gin. Four years before he fell down a trap-door, and fractured two ribs on the left side. From that time he had had almost constant pains in the region of the *right* kidney, with occasional, although slight hæmaturia, to which, as he states, he had been more or less subject from childhood. About six months after his accident he suffered from intense pain in the course of the right ureter, followed by retention of urine, which was relieved by the passage of an oval calculus. He remained tolerably well until a year ago, when, after another similar attack, a second calculus escaped. From this time he remained free from complaint, except the occasional discharge of white sand in his urine, until Sunday, February 19th. On the evening of that day he was attacked with what he regarded as colic, attended with excessive vomiting; this continued until February 21st, when he was relieved by the bowels acting.

For six months before the man came under my care he had been subject to profuse nocturnal perspiration, and his skin acted copiously on slight exertion during the day. The desire to pass urine, which had been very frequent since the passage of the first calculus, had of late much increased, so that he was called upon to empty the bladder a dozen times a day. He was much emaciated, his countenance pale and haggard, his manner anxious; pulse 100, soft; tongue clean; complained of heavy aching pains across the loins. The calculi were brought to me, and on analysis I found them to consist of the triple phosphate, with a small quantity of phosphate of lime. Urine 35 ounces in twenty-four hours.

February 25th.—*Urine passed at night.*—Specific gravity 1·020, neutral to litmus paper, deep brandy-coloured, with a copious white crystalline sediment of the triple phosphate mixed with mucus. A deposit of phosphate of lime occurred on the application of heat.

Morning urine.—Same as the night specimen, but the sediment more copious.

February 26th.—*Urine of twenty-four hours* only 22½ ounces, faintly alkaline and brandy-coloured. Specific gravity 1·022, no deposition by heat. Sediment copious, and as before consisted of triple salts. The small bulk and high colour of the urine of the last two days was attributable to rather copious purging from an aloetic aperient he had been taking.

A nutritious diet was ordered, and a flannel bandage to the loins.

℞ Acidi Nitrici diluti, ♏xx ter die ex. dec. sarsæ. co. cyatho.

February 28.	Urine 35 oz.	Faintly alkaline to litmus, and loaded with phosphatic deposits.
March 1.	—— 42 oz.	
„ 2.	—— 40 oz.	
„ 3.	—— 57 oz. sp. gr. 1·015	

March 3d.—The dose of acid had been gradually increased to half a drachm. The urine, in increasing in quantity, had become paler and whey-like; the morning and evening specimens exactly corresponded, and both contained a copious sediment, which to the naked eye resembled pus. It, however, consisted of large prisms of phosphate mixed with very little mucus. The night specimen only deposited phosphate of lime on applying heat. All the urine contained a small quantity of albumen.

The patient felt better, and was nearly free from a severe lumbar pain, which had been distressing a week before.

Rep. omnia.

March 5th. Perspiration at night less intense.

March 4th.	Urine 47 ounces	Sp. gr. 1·019 neutral, deposit copious.
„ 5th.	—— 45 ounces	
„ 6th.	—— 60 ounces	Sp. gr. 1·016 neutral, deposit still copious.
„ 7th.	—— 70 ounces	

„ 10th. Sufficiently relieved to enter business; he thought the urine continued increasing, but he had not measured it. Sp. gr. 1·015 neutral.

April 7th.—Improving slowly in health, urine still profuse and pale, still copiously depositing phosphates. Complained of return of lumbar pain.

Applic. emp. opii regioni renum.
Acidi benzoici, gr. vj bis die.

14th.—Urine certainly improved; a mere mucous cloud in the morning specimen, 1·014; night specimen, 1·014: both slightly acid for the first time, and containing hippurate of ammonia. He passes 80 ounces in twenty-four hours.—P.

21st.—Much the same in health; urine the same in quantity and density, but a rather copious deposition of phosphates has occurred. He looked as emaciated as ever, but declared he felt fit for all his duties. He wished to leave off his medical treatment.

October 29th.—I again saw him; his general health was improved, and he

was stouter; had had but one attack of pain in the kidney since I saw him. He still passed a very large quantity of urine containing a small quantity of phosphates in diffusion, quite neutral to test-paper. Specific gravity 1·015. His only complaint now was a want of power on contracting the bladder, being often obliged to use powerful efforts to expel the urine. There was no stricture, but he had found great relief to his symptom by emptying the bladder with an elastic catheter every night. He effected this himself, and was then enabled to get a good night's rest.

November 5th.—Much the same; urine 50 ounces in twenty-four hours.

August 2d, 1844.—Tolerably comfortable in health; urine still pale, copious, and neutral, without sediment, but soon by heat lets fall a deposit of phosphate of lime.

Phosphatic Deposits connected with some local lesion of the Urinary Organs.

295. The third class of cases, or those in which the phosphates are probably entirely secreted with unhealthy mucus from a diseased lining membrane of the bladder, are familiar to every practitioner. Chronic cystitis or cystorrhœa, and retention of urine, from stricture of the urethra or enlarged prostate, may, and often do, lead to this state of things. Here, of course, the primary affection, rather than its effect, the deposit of phosphates, must be the great object of treatment. The urine is often very fetid and pale, sometimes green, and almost viscid from the abundance of mucus. On placing some of the latter between plates of glass under the microscope, abundant crystals of the triple phosphate are seen entangled in it. One point of great practical consequence must be borne in mind in forming a prognosis from the state of the urine, viz., not to regard it as ammoniacal, because the odour is offensive; and not to consider the deposit as purulent because it looks so. A piece of litmus paper will often show the urine to be neutral, and sometimes

even acid, whilst microscopic inspection often proves the puriform appearance of the urine to be owing to an admixture of phosphates with mucus. For want of these precautions, I have seen some cases regarded as almost hopeless, which afterwards yielded to judicious treatment. It is quite certain that the mucous membrane of the bladder may, under the influence of chronic inflammation, secrete so much of the earthy phosphates and unhealthy mucus as to render the urine puriform and offensive, without having necessarily undergone any structural change.

296. Several cases have occurred to me in practice, in which the kind of urine just referred to was secreted for a long time, and yet yielded readily to treatment. In these, the greatest good has arisen from freeing the bladder from the phosphates which appear almost to incrust it, by acid injections. In this way, cases have occasionally yielded which have quite defied all other treatment. The following case is a good illustration of this, and I record it in the hope of drawing particular attention to this form of phosphatic cystitis, if a name be required for the disease.

Phosphatic cystitis co-existing with pregnancy and vaginitis?—Discharge of phosphatic calculi—Cure by injection.

Mrs. K—, a fair and delicate-looking lady, 34 years of age, residing in Essex, was married in 1832, and had nine children in the succeeding ten years, being pregnant of a tenth when she came under my notice in May, 1842. She appeared to have enjoyed good health up to December, 1841, when, without any assignable cause, she had severe scalding in micturition, with considerable irritability of bladder. These symptoms rapidly increased in severity, and soon afterwards the urine became loaded with mucus, occasionally streaked with blood. She continued getting worse until March, 1842, when her sufferings became intense; she had frequent desire to pass water every

few minutes, with most distressing straining, especially after each attempt at emptying the bladder; this almost entirely deprived her of sleep. The urine was thick, fetid, and let fall a copious deposit, which was considered as purulent; although acid when first passed, it soon became ammoniacal. About this time, as a calculus was suspected, a sound was passed; this gave rise to the most excruciating pain, but no stone was detected. She suffered severely from hæmorrhoids, and sexual intercourse was attended with positive torture, so that from her own account her life became a miserable burden of woes. From the report of the very experienced surgeon under whose care this lady was (Dr. May, of Maldon) it appears that the bladder was decidedly thickened. In May, 1842, I was consulted by letter, the patient being then three months pregnant, and two specimens of urine, which were described as being purulent and bloody, were sent up.

On examination I found the specific gravity of the urine to be only 1·009; it was opaque and rather green; odour extremely fetid, although faintly acid to litmus paper. A thick creamy deposit, equal in volume to one fourth of the whole, occupied the bottom of the bottle. The deposit, which bore the closest resemblance to pus I ever saw, was examined by placing a portion between two slips of glass under the microscope. It consisted of mucous particles, with a few blood-discs, and myriads of large prismatic crystals of the triple phosphate, mixed with amorphous phosphate of lime. On pouring the lower layers of the urine containing the deposit from one vessel to another, it formed a nearly continuous rope, and entangled some small coagula of blood. But mere traces of albumen were found in the urine. I suggested a nutritious diet, and

> Pil. Saponis comp. gr. v, pro. suppositorio omni nocte.
> Acidi Hydrochlorici diluti ♏x, dosi ad ♏xxx gradatim adaucta, ter die ex. Dec. Sarsæ co.

In a fortnight (May 20th) I received a report from Dr. May, with another specimen of the urine, and some irregular calculous masses the size of peas, consisting of crystals of triple phosphate with mucus. "The poor lady tells me that manual aid was required to remove them from the orifice of the meatus, some hæmorrhage followed, and continued for a few days. The deposit bears a less proportion to the urine than it did, and the intervals between the attempts made to empty the bladder are longer. The recumbent position increases her uneasiness, and renders micturition more frequent (about twice in an hour). An aggravated condition of habitual hæmorrhoids has rendered it necessary to substitute an anodyne draught for the suppositories. She has continued the use of the acid, and she has certainly not lost

ground: on the contrary, she appears stronger. Within the last few days the legs had become œdematous; this has been the case in previous pregnancies, but not at so early a period." I then suggested the daily careful injection into the bladder of acidi hydrochlorici, ♏x, vini opii, ♏xx, in barley-water, in the hope of dissolving and bringing away some of the phosphatic masses which I suspected to be in the bladder, and thus remove one source of irritation. A poultice of conium leaves was directed to be placed over the pubes, and the recumbent position enjoined.

In a few weeks, I received a letter from my friend, Dr. Baker of Maldon, who had seen the patient in consultation with Dr. May; he states, "I am happy to say that Mrs. K— has derived infinite benefit from the use of the injection into the bladder. She could not, previously to her injection, retain her urine for twenty minutes, and then the pain and straining was most distressing; she can now retain it four hours without pain, and there is no appearance of deposit." I had an opportunity of seeing this patient with Dr. Baker, on June 19th, on being called to Maldon to see another case; she was well, and progressing comfortably with her pregnancy.

It is rather a curious circumstance that I was consulted in the spring of the following year, by the son of this lady, for a calculous affection, the urine being loaded with triple phosphate.

297. I cannot speak too highly of the extreme advantage obtained, in almost every case where phosphatic alkaline urine exists, by washing out the bladder by means of injections of warm water. Even when the urine is loaded with alkaline mucus mixed with basic phosphates, so often the case when the bladder is unable to expel its contents from enlarged prostate, or from spinal paralysis, the injection of warm water so as to wash out the bladder effectually two or three times a week is of the utmost value. It is quite remarkable how suddenly the secretion of mucus and phosphates will decrease by this mode of treatment; after two or three repetitions of the injection, the urine, which a few days before was thick and ropy, becomes transparent and healthy. It sometimes happens that the distension of the bladder by a sufficiently copious injection excites pain, and hence is ill borne by the patient. This incon-

venience may be prevented by using the double canula catheter, by which the water entering the bladder from an opening at the end of the catheter, after washing the walls of the viscus, escapes by the second aperture, and hence all distension is prevented.*

Deposits of Carbonate of Lime.

298. It has been already stated that carbonate of lime often occurs in small proportions in deposits of earthy phosphates, when the urine is decidedly alkaline. Its origin may then be explained by a decomposition of phosphate of lime by the carbonate of ammonia which replaces the urea. In this state, the carbonate of lime simply appears as an amorphous powder, and its presence may easily be recognised by the addition of any dilute acid, which dissolves it with effervescence. Care must, however, be taken to wash the deposit with water before adding the acid, for unless all traces of adherent carbonate of ammonia are removed, an effervescence will be excited by the acid, whether the calcareous salt be present or not.

Very rarely, the carbonate is found crystallized in dense stellæ, affecting the circular form, and apparently composed of excessively slender prisms (rhomboids?) cohering at the centre (fig. 58). The few instances of this kind I have met with occurred in neutral or faintly acid urine, a condition probably necessary to ensure the regular structure of the little crystalline masses. Polarized light shows that the

* An excellent double canula elastic catheter has been constructed for this purpose by Mr. Weedon, of Hart-street.

structure of the mass is regular, its density decreasing with the distance from the centre, for a black cross

Fig. 58.

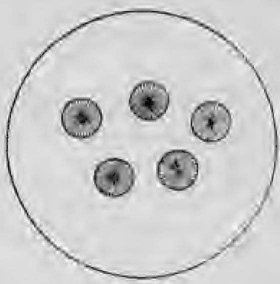

Fig. 59.

becomes visible in each, on properly arranging the calc-spar prisms of the polarizing microscope.

299. Deposits of carbonate of lime are of constant occurrence in the urine of herbivora. These may be readily collected for examination from the urine of the horse, in which they occur spontaneously. When examined by the microscope, after being washed with water, the particles of the carbonate are observed to be small transparent spheres, like globules of glass, and strongly refracting light. Allowed to dry, and examined after immersion in Canada balsam, their structure is beautifully distinct. Each sphere being made up of myriads of minute needles radiating from a common centre (fig. 59); the whole having a circular and well-defined outline, in which respect they differ greatly from the carbonate deposited from human urine. With polarized light, these interesting objects present a series of concentric coloured rings traversed by a black cross. These beautiful little bodies present a remarkable resemblance to pearls, the well-known concretions of the pearl-oyster. Indeed, they

may almost be regarded as urinary pearls. I have some in my possession from the bladder of an ox, presented to me by my friend Mr. Rose, of Swaffham, larger than mustard-seeds, and forming really good pearls. Some of the same kind have been described by my colleague, Dr. Alfred Taylor.

In the urine of the horse, large crystals of oxalate of lime occur mixed with these spheres of carbonate of lime, and probably originating from the presence of sorrel (*Rumex Acetosa*) in the hay on which the animal had been fed. The oxalate is generally in the octohedral form and amber-coloured, but my friend Mr. Havers has shown me specimens in which the dumb-bell crystals co-existed with the ordinary oxalate and carbonate.*

Some few cases are recorded, in which little concretions and gravel of carbonate of lime have been passed in the urine, as if an excess of lime had been eliminated without its usual adjunct, phosphoric acid. I have, however, never met with any examples of this kind, although I have detected carbonate of lime in phosphatic calculi, both mixed with the mass of the concretion, or more rarely forming a distinct stratum.

Carbonate of magnesia is said to occur occasionally in phosphatic deposits, its presence being in all probability due to the decomposition of phosphate of magnesia by carbonate of ammonia (metamorphosed urea).

Deposits of Silicic Acid.

300. Silicic acid exists in infinitesimally small quan-

* The carbonate of lime occurs occasionally in the form of dumb-bells, of which a representation is given in atlas accompanying Lehman's work, Plate 1, fig. 2, by Dr. Otto Funke.

tities in some of the animal fluids, and therefore may possibly be met with as an urinary deposit. It was found in crystals, forming part of a calculous concretion, by Dr. Yellowley,[77] and some other instances of its occurrence have been recorded. Lassaigne[78] found a calculus consisting of pure silicic acid in the urethra of a lamb, and Wurzer[79] has given the analysis of one removed from an ox, in which silicic acid existed to the amount of thirty-eight per cent.

It is, however, very necessary to be on one's guard respecting silicious concretions; for as there is a popular notion that calculous matter is *bonâ fide* gravel, whenever an imposition is intended, a silicious pebble is usually chosen to deceive the medical attendant. I have met with repeated instances of this, in which common rolled pebbles of quartz have been placed in my hands, with the assertion that they were actually passed from the bladder. This has usually occurred in hysterical girls, who laboured under that most unintelligibly morbid desire of deceiving the doctor, by representing themselves as afflicted with some disease of the genito-urinary organs. I have heard of instances in which such pebbles have actually been thrust by a girl into her own urethra, and thus have reached the bladder. In a case mentioned to me by Dr. Christison, a piece of chlorite slate was found forming part of the supposed calculus, thus attesting its true origin. Within the last few days a young lady was brought to me for the purpose of being treated for a calculous affection, for which she had been under the care of her family attendant in the country. She had deceived him by exhibiting to him considerable masses of common pearl-spar, and she brought me a large quantity of the same substance in a bottle. She appeared to be excessively indignant on my telling her that this mineral could

not be derived from the bladder. A case occurred many years ago in St. Thomas's Hospital, in which the late Mr. Cline operated, and removed a quantity of common coals from the bladder of a patient. Not long ago a gentleman had a calculus crushed by my colleague, Mr. Bransby B. Cooper. The case made a great impression on several members of his family, and none more so than a delicate susceptible nephew. He soon after complained of difficulty of micturition, passed an abundance of supposed gravel, and at last his urethra was blocked up by a calculus, which, however, with a little aid from his uncle was removed. This calculus, as well as the gravel, he declared he had passed, although in quantity large enough to fill a small wine-glass, was placed in my hands. All these presumed calculi were angular fragments of silicious pebbles, and owed their origin to a neighbouring garden, and not to the bladder of this young gentleman. The reason for this imposition was quite unintelligible.

301. As silicic acid has been found in calculi by such excellent observers as the late Dr. Yellowley and Dr. Venables, and as the ox and lamb mentioned by Wurzer and Lassaigne could hardly have been supposed to have put the silicious matter into their own bladders, the occasional possible occurrence of silicic acid in urinary deposits and concretions must be conceded. Still, that it is extremely rare, all experience has proved, as indeed might be anticipated from the chemical relations of this very refractory substance.

CHAPTER XI.

DEPOSITS OF ABNORMAL BLUE OR BLACK COLOURING MATTERS.

Blue and black deposits, 302—Braconnot's cyanourine, 303—Diagnosis of, 304—Schmidt's blue pigment, 305—Indigo, 306—Diagnosis of, 307—Prussian blue, 308—Alleged presence of cyanate of ammonia, 309—Diagnosis of Prussian blue, 310—Black deposits described by Braconnot, Marcet, Dulk, and Dr. Hughes, 311.

302. In addition to the various tints communicated to urine by bile and blood (61, 314), certain peculiar colouring matters, strictly the products of diseased action, are occasionally, although very rarely, met with. These generally communicate to the urine a blue or black colour. Three different blue pigments, at least, have been met with, viz., cyanourine, indigo, and percyanide of iron, and probably two black ones, melanourine and melanic acid. Blue, green, and black urine has been described by the ancients, but it is probable that the variety of tints so often mentioned by all physicians since Hippocrates, were produced by blood or bile modified by the state of the urine.

303. *Cyanourine* was first discovered by Braconnot,[80] and has since been observed by Spangenberg, Garnier, Delens, and others. Urine containing it possesses a

deep blue colour, and by repose lets it fall as a blue deposit capable of being readily separated by the filter. It may be freed from adhering mucus, uric acid, phosphates, &c., by washing with water, and digesting it in hot diluted sulphuric acid. The cyanourine may be precipitated from the acid solution by the careful addition of magnesia. It may also be obtained by boiling the blue deposit from the urine in alcohol, and evaporating the solution to dryness.

304. *Diagnostic characters.*—Cyanourine is a tasteless and inodorous dark blue powder, scarcely soluble in water, merely at a boiling heat communicating to it a brown colour, which on the addition of an acid, becomes red; moderately soluble in boiling alcohol, being partly deposited on cooling. Diluted acids dissolve it, the solution being brown or red, according to the proportion of acid present. The solution in sulphuric acid leaves, by evaporation, a carmine-red extract, which dissolves in water, forming a brown fluid. Ammonia, lime-water, and magnesia, precipitate it unchanged from its acid solution. Hot solutions of alkaline carbonates dissolve cyanourine, forming a red, whilst the pure alkalies yield a brown solution. Nitric acid converts this substance, like indigo, into nitro-picric acid. Heated in a glass tube, it forms an oily fluid which burns to a bulky ash.

Cyanourine is distinguished from indigo by not subliming when heated in a tube, and from percyanide of iron by not yielding sesqui-oxide of iron when digested with carbonate of potass.

305. Another modification of blue colouring matter has been described by Dr. Schmidt as occasionally occurring in the urine of patients under hydropathic treatment at Gräfenberg.[113] The deposit consisted of ovoid globules about one third the size of a blood-corpuscle, and of a

fine blue colour. It was partially soluble in hot ether and alcohol, forming blue solutions. Neither dilute sulphuric acid nor ammonia acted on it. Oxalic acid dissolved it, forming a blue solution. Potass, aided by heat, destroyed its colour. No uric acid could be detected.

The origin of this pigment is quite obscure; it is probably traceable to some metamorphic change in a protein compound; for we know that albumen, when boiled with hydrochloric acid, forms a bluish solution. Also, when vegetable gluten, a body closely allied to albumen, spontaneously decomposes in the air, it becomes partly converted into a blue substance. Dr. Heller has lately stated that these curious deposits are merely metamorphosed uroxanthin or yellow colouring matter of urine, and has applied the name of uroglaucine to the blue pigment. He assumes, therefore, that it is identical with what I have described as purpurine, produced by the action of hydrochloric acid on previously warmed urine. The statements of Heller, however, are mixed up with certain inaccuracies, and can hardly be admitted without more minute investigation.

The pathological indications of these substances are quite unknown.

306. *Indigo.*—This pigment, when taken into the stomach, as is occasionally done in the empirical treatment of epilepsy, finds its way into the urine, forming a blue deposit. It, however, appears probable that indigo has occasionally been generated in the animal economy, and instances of this kind have occurred to Drs. Prout[81] and Simon.[82] When this substance is present, the urine acquires a dark blue colour, and by repose a deposit of the same hue falls. This, when collected on a filter, presents all the well-known chemical characters of indigo.

The composition of this substance (C_{16}, N, H_5, O_2),

approaches sufficiently close to that of some animal products to render its occasional development in the organism a matter of high probability.*

307. *Diagnostic characters of indigo.*—This substance dissolves in strong sulphuric acid, forming a purple solution. Nitric acid converts it into nitro-picric acid. Carefully heated in a tube, it sublimes in purplish-red crystals. By de-oxidizing agents it is bleached, and

* Dr. Hassall, in the 'Philosophical Transactions' (vol. cxliv), has a paper on this subject, in which he forms the following conclusions. That blue indigo is frequently formed in human urine, and, according to its quantity, imparts to the urine a deep green or blueish-green colour; sometimes even forms a pellicle of nearly pure indigo over the whole surface of the liquid, at other times the quantity is so small as only to be detected by the microscope. That exposure to the air for some days, or some cause facilitating oxygenation, is necessary for the development of the indigo. That it is often accompanied by a brown extractive, in considerable quantities, closely resembling, in its composition and chemical reactions, hæmatin. That the source of the indigo probably is altered hæmatin, a modified urine pigment (cyanourine and uroglaucine). That the urines in which the indigo occurred in largest quantities are of a pale straw colour, readily becoming turbid and alkaline, and of low specific gravity. That it does not occur in healthy urine, but frequently, though not exclusively, in the urines of patients the subjects of Bright's disease, or pulmonary affections. That it appears to be associated rather with a general morbid condition than with affection of any particular organs.

The relation between indigo and hæmatin appears, by comparing one atom of hæmatin with three of indigo.

$$\begin{array}{lll} 1 \text{ atom of hæmatin} & = & C^{44}\ H^{22}\ N^{3}\ O^{6} \\ 3 \quad ,, \quad \text{indigo} & = & C^{48}\ H^{15}\ N^{3}\ O^{6}, \end{array}$$

Or, according to the suggestion of Dr. Letheby, the relation stands thus:

$$\left.\begin{array}{lr} & \text{C} \quad \text{H} \quad \text{N} \quad \text{O} \\ 1 \text{ atom of hæmatin} = & 44+22+3 \quad 6 \\ 2 \quad ,, \quad \text{water} \quad = & 2 \qquad 2 \\ \hline & 44+24+3+8 \end{array}\right\} = \left\{\begin{array}{lr} & \text{C} \quad \text{H} \quad \text{N} \quad \text{O} \\ 2 \text{ atoms of indigo} = & 32+12+2+4 \\ 1 \quad ,, \quad \text{leucine} = & 12+12+1+4 \\ \hline & 44+24+3+8 \end{array}\right.$$

white indigo produced; this, by exposure to the air, loses an atom of hydrogen by oxidation, and becomes blue.

Simon[83] gives the following as the best mode of detecting indigo in a blue deposit.

Heat the deposit with a little grape-sugar in a mixture of alcohol and liquor potassæ, the blue colour disappears and a yellow solution is obtained. By agitation and exposure to the air the fluid assumes a red, and eventually a green colour, from the reproduction of blue indigo.

The pathological indications of deposits of indigo are unknown. Whenever they are met with, care should be taken to investigate the patient's history, so as to discover whether this substance had been previously medicinally administered.

308. *Sesqui-ferro-cyanide of iron, or Prussian blue.*—This substance was first found by M. Julia Fontanelle[84] in the urine of a boy residing at Mont-Louis in the Pyrenees. He was labouring under severe colic, attributed to his having swallowed a quantity of ink. The blue deposit continued for a day or two after the attack, leaving the urine of its natural colour, but containing some soluble cyanide, as a blue precipitate was produced on the addition of a salt of iron. Several other instances of Prussian blue deposits have occurred, and it is remarkable that in most of them iron has been accidentally or intentionally taken. These deposits are said to be artificially produced by giving to a patient who has been taking some preparations of iron, a few doses of ferrocyanide of potassium.

The origin of the cyanogen of the blue deposit can be readily explained from the known composition of urea. We have seen that this substance may be regarded as a carbonate of ammonia (30), but it may also be considered as a cyanate of that base; thus—

		C	N	H	O
1 atom cyanic acid = { 1 atom cyanogen	=	2	+1		
1 „ oxygen	=				1
1 „ ammonia	=		1	+3	
1 „ water	=			1	+1
Composition of an atom of urea	=	2	+2	+4	+2

As Prussian blue consists of a combination of iron with cyanogen, if any cause determines the resolution of urea into the above proximate elements, and iron be present, a precipitate of the sesqui-ferro-cyanide must be the necessary result.

309. It has been asserted by Professor Pietro Piretti of Rome,[134] that when persons labour under the influence of malarious poison, the urea normally present in the urine is really replaced by cyanate of ammonia, and which can be obtained by careful evaporation. He adds, that during the successful treatment of ague by valerianate of quina, the cyanate gradually disappears, and is replaced by true urea.

310. *Diagnostic characters of Prussian blue.*—A blue powder insoluble in water and alcohol. By digestion with liquor potassæ its colour is destroyed, sesqui-oxide of iron being set free, and a yellow solution of ferrocyanide of potassium formed. This solution is precipitated blue by sesqui-salts of iron, and hair-brown by sulphate of copper.

The pathological indications of these deposits are unknown.

311. *Melanourine and melanic acid.*—Under these names have been described some black pigments which have been met with in urine. Their chemical properties are very ill defined, and their origin and pathology

alike obscure. It is more than probable that, in some instances at least, these pigments ought to be regarded rather as altered colouring matter of blood than anything else.

a. Braconnot[85] has described a black matter which he regarded as a weak salifiable base; it occurred in the blue urine (286), and remained in solution after the cyanourine fell. It was obtained after the latter had fallen, by merely boiling the clear urine, when the black matter coagulated and became insoluble. It in all probability was merely modified hæmatosine.

b. The late Dr. Marcet[86] met with a black matter in the urine of a child, unaccompanied by the ordinary constituents of the secretion. To this substance the name of melanic acid was applied by Dr. Prout. The urine in which it occurred was like ink; it slowly deposited black flocculi after the addition of an acid. The black matter was insoluble in water and alcohol; nitric and sulphuric acids dissolve it, forming a black solution, which by dilution deposited the pigment unchanged. Alkalies and their carbonates dissolved it, and acids precipitated it from its solution. Its alkaline solution produced brown precipitates on the addition of metallic salts.

c. Professor Dulk, of Königsberg, has described a curious kind of urine of a blackish grey colour, passed by a patient affected with hepatic disease. On filtering it, a yellow fluid, which was merely diluted urine, passed through, and a black matter was collected on the paper. This was slightly soluble in nitric and hydrochloric acids; the solution being precipitated by tincture of galls.

Professor Dulk suggests that this pigment was merely

a highly carbonised hæmatosine, arising from the imperfect performance of the hepatic functions.

d. Dr. Hughes, in the 'Guy's Hospital Reports,' (vol. ii, p. 52, 3d series,) has narrated a few cases of black urine. In the first case, which was under his own care, the urine, after the administration of creosote to allay vomiting, was of a dirty or brownish black colour, clear, unaltered by heat, nitric acid, or liquor potassæ, even on boiling—without sediment, and remained unchanged in appearance after being kept in an open vessel for several days. There were no traces of blood-globules, or of any other solid substance, under the microscope. After death, miliary tubercles, and some recent pneumonic deposit, were found in the lungs. The cavity of the peritoneum was obliterated by strumous peritonitis. The structure of the liver was fatty. The common iliac, external iliac, and the commencement of the femoral vein of the left side were filled with a clot of fibrin adherent to the coats of the vessel, and soft and whitish in the centre. The condition of bladder and kidneys is not mentioned. The second case was one of fever; the urine was of a bright blue colour, but was thrown away by the nurse before any analysis could be made. The third was a case of strumous peritonitis, in which a black deposit occurred upon boiling the urine with nitric acid. These two cases were furnished by Dr. Wilks. Dr. Hughes in all alludes to nine cases, but excludes two, inasmuch as one of them was not watched, so that the colouring matter might have been improperly introduced, and in the other the urine was not examined. Of the remaining seven, creosote had been taken internally in three cases; in two, tar had been applied externally for psoriasis; in six cases the urine was black and clear, and was but slightly, if at

all, affected by chemical reagents. In the seventh, a dense, black precipitate was thrown down by heat and nitric acid. Dr. Odling states, concerning this urine, that the black precipitate, on subsequent exposure, became an indigo-blue deposit. He considers that creosote and indigo belonging to two closely allied chemical families throws light upon its nature.

CHAPTER XII.

NON-CRYSTALLINE ORGANIC DEPOSITS.

Use of the microscope, 312—Elements of blood in urine, 313—Diagnosis, 314—Albumen, 315—Tests for, 317—Casts of tubuli, 318—Hæmatosine, 320—Microscopic characters of blood-discs, 321—Pathological indications, 322—Therapeutical indications, 323—of albumen, 325—Purulent urine, 327—Diagnosis, 328—Microscopic characters, 329—Pathological indications, 330—Mucous urine, 331—Tests for, 332—Microscopic characters, 333—Pathological indications, 334—Therapeutical indications, 335—Value of injections, 337—Large organic globules, 338—Small globules, 340—Epithelial débris, 341—Spermatic urine, 342—Microscopic characters, 343—Connection with oxalate of lime, 344—Pathological indications, 345—Treatment, 346—Growth of torula in urine, 348—Microscopic characters, 349—Presence of sugar in urine, 350—Tests for, and pathological and therapeutical indications of, 351—Fungoid growths, 352—Development of vibrio lineola, 354—Milky urine, 356—Kiestein, 357—Diagnosis, 358—Connection with pregnancy, 359—Fatty and oily urine, 367—Fat in cells, 368—Chemical characters of chylous urine, 370—Microscopic characters, 371—Pathological indications, 372—Case of, 373—Cases in the Mauritius, 375—Dr. Jones's researches, 376—Uro-stealith, 378—Diagnosis of, 379—Characters of urine, 380—Pathological indications, 381.

312. The elements of the urinary deposits already examined, are capable of being easily recognised by their crystalline form or chemical properties. Those which we have now to investigate are organic substances, often possessing organization, and sometimes enjoying an independent vitality. In the detection of

these in deposits, microscopical examination is in almost every instance quite indispensable, and in many furnishes the only means for discovering their true nature.

The best mode of examining these deposits microscopically, is to allow the urine to repose in a glass cylindrical vessel for a short time, decant the upper nine tenths of the fluid, and then place a drop of the residue on a plate of glass. Carefully cover it with a piece of very thin glass, and submit it to the microscope. A good achromatic objective of a quarter of an inch focus is generally sufficient for all these investigations, but it is sometimes necessary to use one of one seventh or one eighth of an inch, when the object is very minute; but to a person familiar with these observations a good half-inch glass is sufficient for almost all cases.

ELEMENTS OF BLOOD.

313. The blood may be regarded as made up of red corpuscles, floating in a fluid holding in solution the soluble elements of the blood, and possessing the power of spontaneous coagulation in consequence of the presence of fibrin. To this fluid the name of *liquor sanguinis* is conventionally applied; a term first, I believe, used by my colleague, Dr. Babington, with whose ingenious and important researches on the blood most are well acquainted. All, or any, of the elements of the blood may find their way into the urine, either as the result of mechanical violence to the kidney or any part of the genito-urinary track, of the irritation of a calculus, of organic disease, or any breach of surface of the mucous membrane of the kidneys or bladder; or of sufficient pressure upon the renal veins to prevent the return of blood from the kidneys to the cavæ (322). We may find

in the urine serum of blood, alone or accompanied by red particles; sometimes the liquor sanguinis is alone effused, and containing but a small proportion of colouring matter; or more frequently, all the elements of blood may be poured out together. Of the first of these, the urine of morbus Brightii, and of cases of anasarca resulting from scarlatina, are good examples; in these the urine is characterised by the presence of albumen, and in acute cases presents the dingy or smoky aspect characteristic of the presence of colouring matter of blood, or of entire blood-corpuscles. Of the second condition, the urine in fungous hæmatodes of the kidney furnishes a good example; this is often observed to be of the colour of infusion of roses whilst warm, and on cooling solidifies into a pink transparent mass, like red-currant jelly, retaining the figure of the vessel. Every case of idiopathic or symptomatic hæmaturia affords examples of the presence of all the elements of blood in the secretion.

314. *Diagnosis of urine containing blood.*—When blood is effused in any considerable quantity in the urine, it coagulates in to blackish masses like pieces of black-currant jelly; and when it partly coagulates in the bladder, linear masses of clot of nearly the shape of leeches are passed from the urethra, often to the great distress of the patient, by producing temporary suppression of urine. Even after this coagulation, the urine retains a port-wine colour, and the microscope detects an abundance of entire blood-corpuscles; although in a great proportion of them, the investing membranes have given way, and the coloured contents becomes diffused through the urine. If too small a quantity of blood has been effused to give a decided red colour to the urine, it will be frequently found possessing merely a dirty, dingy hue;

less frequently being of a pink colour like the washings of flesh. In either case a sufficient number of blood-corpuscles will subside by repose to allow of their being readily identified by the microscope (321).

The coagulation of urine by repose will readily indicate the presence of the liquor sanguinis, as the fibrin it contains is the only spontaneously coagulating substance in the body. This element is very rarely effused by itself, being generally mixed with blood-corpuscles, giving the coagulum a red colour; or with a fatty matter, which causes the coagulum to assume the appearance of *blancmange* (370). Fibrin is, however, sometimes found deposited in the form of minute linear tubular masses, each being probably the cast of one of the uriniferous tubules (319). The red colouring matter, or hæmatosine, and the albumen of serum, do not present characters always sufficiently satisfactory to allow of their being identified without the application of re-agents.

315. *Albumen* may readily be detected in urine containing it, by the production of an opacity by the application of heat. This experiment, where any amount of accuracy is required, should always be performed in a clean test-tube, heated over a spirit-lamp. The common mode of heating it in a metallic spoon over a candle, although answering the purpose very tolerably when a glass tube cannot be procured, is infinitely inferior in the delicacy of its indications. But if a spoon is used, it should be half-filled with the urine, and the extreme end of the bowl be placed over the flame of a candle. In this way the thin layer of urine near the end of the spoon soon boils, and the white striæ of this coagulated albumen which gradually diffuse themselves through the cooler parts of the fluid, enable a very small

quantity of this substance to be detected. If a large quantity of albumen be present, the urine will become quite solid on the application of heat, and will vary from this state to the production of a mere opalescence, according to the quantity existing in the urine. It is a curious fact, that the greatest amount of coagulation by heat, is often found in urine either free from or containing but a small quantity of the colouring matter of blood. The dingy-red urine in granular disease of the kidneys, generally deposits less albumen by heat than when it is straw-coloured, and nearly free from hæmatosine.

316. Albumen does not require actual ebullition for its coagulation by heat; if any be present in urine, the latter becomes opaque before a bubble of vapour is evolved.

The addition of a drop of nitric acid to albuminous urine immediately produces a copious coagulation of the albumen, but if only mere traces of the latter be present, the opacity first produced will disappear by agitation, and will re-appear by the addition of a second drop of the acid. A drop of a mixture of one part of nitric acid and three of hydrochloric acid, is much more decided in its effects, and more delicate in its indications than pure nitric acid. This admits of ready explanation in the evolution of chlorine by the abstraction of hydrogen from the hydrochloric acid, and thus one of the most delicate precipitants of the protein compounds is set free.

Another delicate test consists in the addition of a solution of ferro-cyanide of potassium previously acidulated with acetic acid. This, like the last test, has the inconvenient property of precipitating other protein compounds besides albumen, as mucus, &c.

317. *As a general rule*, if urine becomes opaque by heat and on the addition of nitric acid, albumen is present. It is important to bear in mind that certain sources of fallacy exist when only one of these tests are used.

A. Heat will produce a white precipitate in urine containing an excess of earthy phosphates (261). *Distinguished from albumen by disappearing on the addition of a drop of any acid.*

B. Heat being applied to urine containing deposits of urates, will sometimes, if actual ebullition be prolonged, produce a deposit of an animal matter (tritoxide of protein?) insoluble in nitric acid. This is rare, *but is distinguished from albumen by being deposited only after protracted ebullition.*

C. Nitric acid will often produce white deposits in the urine of patients under the influence of copaiba, cubebs,[83] and perhaps some other resinous diuretics. *Distinguished from albumen in not being produced by heat.*

D. Nitric acid will, in some concentrated urine, as in the scanty secretion of fever, often produce a dense buff-coloured amorphous precipitate of uric acid. *Distinguished from albumen in not being produced by heat.*

E. Albumen may be present in urine and not be precipitated by heat, providing the secretion be alkaline. If, therefore, urine suspected to be albuminous, is capable of restoring the blue colour of reddened litmus paper, *nitric acid must be used as the test*, as albumen, when combined with alkalies, does not coagulate by heat.

F. Albumen may be present and yet escape detection from using dirty test-tubes; a small quantity of an acid, or a little solution of potass, or soda, left in a tube, will prevent the precipitation of albumen by heat from urine boiled in such a tube.

G. It may occasionally happen that albumen may be present in the same incipient or hydrated state in which, according to Dr. Prout, it occurs in chyle.[84] Heat scarcely affects this variety of albumen, except by ebullition; but nitric acid immediately coagulates it. Where but small quantities of albumen are present in urine containing rather more than an average proportion of phosphate of soda, the application of heat scarcely produces any visible opacity until after the addition of an acid, and hence it is possible for the albumen to be erroneously regarded as existing in the hydrated state; a condition which has never occurred to me. In the later stages of diabetes mellitus, I have occasionally found the urine previously warmed rendered opaque on the addition of nitric acid; the precipitated matter appeared to me to resemble some of the oxygenized compounds of protein described by Mülder.

318. A remarkable substance allied to albumen has been detected in the urine by Dr. B. Jones in cases of rickets; it differs from albumen in not being precipitated by heat or nitric acid. But on boiling the urine and allowing it to cool, a precipitate fell, which re-dissolved on the application of heat. Alcohol added to the urine readily coagulated this substance. Dr. Jones considers this substance to be allied to the albuminous matters

(oxides of protein ?) found in buffy coat of inflamed blood and in pus.*

* In certain forms or stages of albuminuria or Bright's disease, or the desquamative nephritis of Dr. Johnson, the urine deposits a sediment, which consists of the altered epithelium, with its exudations, of the urinary passages; it is of a dirty-white hue, easily diffused by agitation, and not unlike mucus, though at once distinguished from it by being dissolved and gelatinized by a solution of potash. I speak of certain forms, as now it is clear that under the head of albuminuria, or Bright's disease, are not only to be enumerated merely various *stages* of the same disease, but really and essentially distinct *forms*, constituting different diseases, varying in their origin, the rapidity of their course, their pathological indications, and in the microscopical appearances of the urinary sediments.

Closely connected with this subject are the names of Bright, Barlow, and Johnson, and I refer with much confidence to their writings, principally contained in the different numbers of the 'Guy's Hospital Reports,' for a full detail of the symptoms and treatment; I also have much satisfaction in alluding to a paper by Dr. Wilks,† in which he sums up clearly, but fully, the opinions held in the Medical School of Guy's, regarding the distinct forms assumed by this disease, as shown by the symptoms during life, and the microscopic appearances after death. I now proceed to notice the microscopic appearances of the sediments.

1. *The renal cells* (fig. 60), when *in situ*, are polygonal‡ bodies, but become spheroidal or sub-spheroidal on detachment; they measure from about $\frac{1}{1400}$ to $\frac{1}{800}$ part of an inch in diameter, and contain nuclei, but are occasionally filled with granules or fat. They seldom occur alone, but are generally found associated with epithelial casts or blood discs, and mark the acute stages of desquamative nephritis, though any temporary irritation of the lining of the renal tubes may cause their detachment and subsequent removal in the urine.

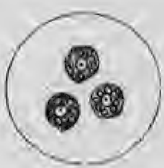

Fig. 60.

True epithelial casts are represented in fig. 61, 1, magnified about 200. They show the earliest deviation from the healthy condition. There may be some

† 'Guy's Hospital Reports,' 2d series, vol. vii.

‡ Kölliker, translation by Sydenham Society.

319. Albumen is occasionally found in the urine in

difference of opinion as to their structure. Some pathologists represent them as arising from the moulding of fibrin which has exuded from the Malpighian bodies, and entangled, in its passage through the tubes, blood corpuscles and the epithelial cells, previously shed by a process of desquamation. Such bodies are certainly found, but I shall refer to them afterwards as rather belonging to what have been called hyaline, or structureless casts. The true

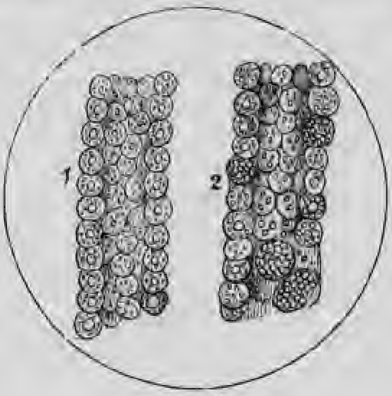

Fig. 61.

epithelial casts are about $\frac{1}{700}$ of an inch in diameter. They are elongated pieces of the epithelial lining of the convoluted renal tubes. The cells which stud their surfaces contain nuclei and granular matter, and are rather more opaque than natural, and in parts detached. These casts, as well as the renal cells, are indicative of the acute stage of morbus Brightii, or desquamative nephritis.

3. *Granular casts*, are represented in fig. 61, 2, and fig. 62, 3, and are of several kinds. The first are similar to the true epithelial casts, and differ from them only in that the cells are more decidedly filled with granular matter, and in points detached, leaving the basement membrane bare. Fig. 61, 2, magnified about 250. These may be called granular epithelial casts. In the next stage the cells appear to have been disintegrated, and the granular matter is thickly sprinkled over the surface (fig. 62, 3). In the next form the surface of the cast is equally sprinkled with granules, but the origin is different; in the former the granules are developed within the cells, even before their separation; but in the latter they are formed from protein compounds secreted

a coagulated state, and presenting a tubular vermicular

within the cavity of the tube. They are found, more especially the latter, in the chronic stage of desquamative nephritis, and are considered by Dr. Todd to have a close relation to chronic gout, and indicate a small contracted kidney with irregular surface, which he calls the gouty kidney. In cases of

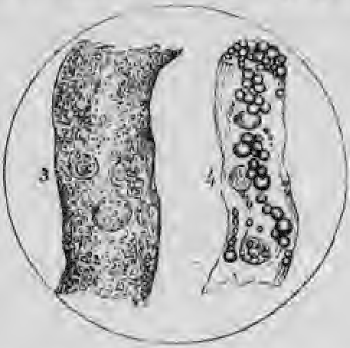

Fig. 62.

the gouty kidney, the urine in the first stage is in appearance healthy, only occasionally albuminous, and the sediment consists mostly of disintegrated epithelium; as the disease advances to the second and third stages the urine becomes paler, and permanently albuminous; and in the last stage contains large waxy or hyaline casts, $\frac{1}{500}$ of an inch in diameter.

4. *Fatty casts* are represented in fig. 62, 4, and are of various kinds. The earliest change is a deposition of fatty matter within the renal cells before their detachment. To the eye they resemble the epithelial casts, except that many of the cells contain fatty matter in the form of granules. In the course of the disease the deposition of fat increases, the cells lose their character, and there appear globules of fat studding a structureless membrane. Dr. Johnson states that the oily or fatty casts, though occasionally occurring as a consequence of acute desquamative nephritis, belong more especially to the non-desquamative form of the disease. The urine in the earlier stage is albuminous, but contains neither epithelium nor casts. As the disease progresses a light cloudy sediment is deposited, which is found to contain small waxy casts of about $\frac{1}{1000}$ of an inch in diameter, with oil globules or oval cells with more or less oily contents. Some of the oil may be the products of the metamorphosis of fibrinous or albuminous exudations.

5. *Hyaline, structureless, or waxy casts*, are of different sizes, and consist

appearance. In this form it has been mistaken for

of fibrinous exudations, whether from the Malpighian bodies or from the walls of the tubes, either before or after epithelial desquamation, and moulded into the tubular form during their passages down the tubes. 1. The smaller size measures about $\frac{1}{1000}$ of an inch in diameter, and are the product of the fibrinous exudation from the Malpighian bodies, while the epithelial surface is unbroken. Their presence marks the acute stage of the non-desquamative form of the disease. 2. The large size measures about $\frac{1}{300}$ of an inch, and appears to originate from fibrinous exudations within the tubes after the de-

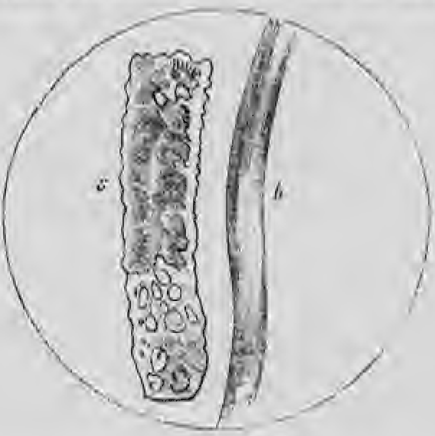

Fig. 63.

tachment of the epithelial cells. Fig. 63, 5 and 6, representing the two sizes, are taken from Dr. Johnson's work. They are rather too coarse; occasionally they appear in the field as mere tubular shades, with perhaps one or wo altered renal cells, or granular matter attached.

6 and 7. *Pus- and blood-casts* are generally formed by the entangling of the pus or blood-corpuscles in the moulded fibrin; in fact are hyaline casts studded with pus-cells or blood-corpuscles. But occasionally they appear as epithelial casts, having the cells either replaced by, or studded with, pus or blood-corpuscles. The latter indicate the existence of acute disease, calculous irritation, or malignant disease. In acute disease the epithelial casts are also present; in cases of calculus the other diagnostic signs will throw light on the nature of the case; and in the third, or malignant

minute hairs (fig. 64). It is of common occurrence in Bright's disease, even in the earlier stages, and the deposit appears to be made up of fibrinous (albuminous) casts of the uriniferous tubules of the kidney. Portions of epithelium are often found adhering to them, generally, according to Dr. G. Johnson, loaded with fat (369). Urine containing

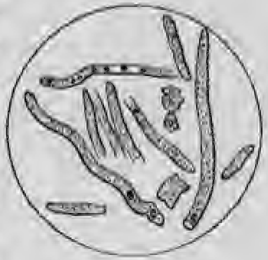

Fig. 64.

these bodies lets them fall by repose in the form of a dirty-white sediment, easily diffused by agitation, and not unlike mucus. A solution of potash dissolves and gelatinizes the deposit, which will at once distinguish it from mucus. The tubular masses of albumen are seldom larger than $\frac{1}{50}$ or $\frac{1}{100}$ inch, generally much shorter, and in diameter correspond closely with that of the tubuli uriniferi, never exceeding $\frac{1}{1000}$ inch. This deposit may be regarded as almost pathognomonic of Bright's disease.

320. *Hæmatosine* ($C_{44}H_{22}N_3O_6Fe$) is regarded as the colouring matter of the blood, normally contained within the delicate sac of the corpuscles, particles, discs, or globules of blood; all these terms being synonymous. It is not

disease, carcinomatous cells will probably be present, and aid the diagnosis. Though in these three instances the investigation of the general symptoms would probably be sufficient, yet when the mind is bent on elucidating a nice point in diagnosis, the microscopic examination is of the utmost value. Pus casts indicate pyelitis, or suppurative disease of the epithelial lining of the pelvis and tubes of the kidney. This may originate in—1, morbid conditions of the blood; 2, the application of external violence; 3, from changes consequent on retention of urine; and 4, from the inflammation caused by calculous irritation.*

* Dr. Johnson, 'On the Diseases of the Kidney.'

known whether it is the product of the metamorphosis of the true colouring matter of the blood, or whether it only bears the same kind of relation to that substance as does coagulated albumen to that principle in its fluid state. It cannot be separated in a soluble condition from the globulin. When pure, it occurs as a dark brown, slightly lustrous mass, which on trituration adheres to the pestle. It has neither taste nor smell; is insoluble in water, alcohol, ether, acetate of the oxide of ethyl, and fatty and volatile oils. Mülder, however, regards it as slightly soluble in fatty and ethereal oils. It dissolves readily in weak alcohol, to which sulphuric or hydrochloric acid has been added, forming a brown solution, which, being saturated with an alkali, assumes a blood-red colour. After trituration with sulphate of potash it dissolves for the most part in water. Even very dilute solution of the caustic alkalies and their carbonates in water or alcohol dissolve it in almost every proportion. Chlorine dissolves the perchloride of iron and throws down white flocculi, soluble in alcohol and ether but not in water, which, dried at 100°, appear as a light coloured powder, unaffected by hydrochloric acid, but soluble in alkalies, forming a reddish solution, consisting of chlorous acid and hæmatosine freed from iron, according to Mülder, who gives the following as the composition of the latter:

Carbon,	44 atoms	65·347
Hydrogen,	22 „	5·445
Nitrogen,	3 „	10·396
Oxygen,	6 „	11·881
Iron,	1 „	6·931
		100·000*

* Lehmann.

When hæmatosine is present, the urine is always more or less coloured by it, and a few entire corpuscles are almost always found floating in the fluid. It never occurs unaccompanied by albumen, and being acted upon by tests in a similar manner, the remarks already made on the latter substance (317) apply equally to hæmatosine, excepting that the deposits produced by heat or nitric acid are always brown instead of white. M. Pariset[105] has proposed the following process for the detection of blood in urine, as least liable to fallacy. Boil the urine and filter it. Brown coagula of hæmatosine and albumen will be left on the filter; pour on these some liquor potassæ, and if hæmatosine be present, a greenish solution will pass through, from which hydrochloric acid will precipitate white coagula of protein. The following, in addition to those mentioned as affecting albumen, are the most serious sources of fallacy in the detection of hæmatosine.

1. *Purpurine*, when present in the urine (184), will often communicate to it so intense a colour as to cause the patient to report his urine to be bloody. *Distinguished by not being affected in colour or transparency at a boiling heat.*

2. *Uric acid*, when present in concentrated urine, as in the first week of fever, is often immediately precipitated by nitric acid, brown coagula, much resembling those of hæmatosine, falling; but really composed of extremely minute crystals of uric acid. *Distinguished by not being affected by heat, and by the microscopic character of the deposit* (124).

3. *Bile*, or at least its colouring ingredient, often tints the urine of a deep brown colour, and may lead to an unfounded suspicion of the presence of blood. One or

other of the following tests will at once detect bile or its colouring matter in a fluid.

a. Pour on a white plate, or sheet of writing-paper, a small quantity of the urine, so as to form an exceedingly thin layer, and carefully allow a drop or two of nitric acid to fall upon it. An immediate play of colours, in which green and pink predominate, will, if the colouring matter of bile be present, appear around the spot where the acid falls.

b. (Pettenkofer's test.)—To a small quantity of the suspected urine in a test-tube, two thirds of its volume of sulphuric acid are to be carefully added, taking care that the mixture, which soon becomes hot, never exceeds a temperature of 144°. Three or four drops of a solution of one part of sugar to four of water are then added, and the mixture shaken. A violet-red colour becomes developed if bile be present. My own experience of this test has not led me to regard it as either a generally useful or trustworthy one, and in applying it there are numerous sources of fallacy to be guarded against, arising chiefly from the action of sulphuric acid on sugar, which developes a red colour in the absence of bile. A mixture of albumen or oil with sugar will, even in very minute quantities, produce a purple or scarlet colour, with sulphuric acid, as Raspail long ago stated.

c. (Heller's test.)—Add to the urine any albuminous fluid, as serum of blood or white of egg; then pour in sufficient nitric acid to produce a considerable albuminous coagulum. On examining this after a short repose, it will be found to possess a bluish or green colour if bile-pigment existed in the urine, whilst, if none were present, the deposited mass will be white or merely slightly yellow.

d. It may occasionally happen that bile may exist in the urine so modified (oxidized?) as not to exhibit the

characteristic reaction with acids. This has been observed in cases of cholera; the urine, although containing modified bile, became merely imperfectly reddened by it. Ammonia then becomes a valuable test, as it produces an immediate deep red colour.[106] The fallacies of this test are the accidental presence of vegetable colouring matters, especially rhubarb, and the newly observed fatty body, stearolith (378).

4. *Hæmatoxylon*, administered as a medicine, will often, by the red colour it communicates to the urine, lead to an unfounded suspicion of the existence of hæmatosine. *Distinguished by the dark precipitate produced by sulphate of iron, and by absence of coagulation by heat.*

5. *Pareira, Chimaphila*, and even *Senna*, will sometimes communicate a dark brown tint to the urine; but the absence of all the characteristics of albumen and hæmatosine, will distinguish it from the colour produced by blood.

321. *Microscopic characters of blood-corpuscles.*— These furnish the readiest and most infallible mode of detecting blood in the urine. To discover them, if the urine possess a red or brown colour, a drop taken from it after agitation will be sufficient to allow their ready detection. But if the urine be barely coloured, it is better to allow it to repose for some hours, and examine a drop from the bottom of the vessel, to which the corpuscles generally sink with readiness.

If blood be recently effused into the bladder from some mechanical injury, the components are observed not only unaltered in figure, but even adhering in rouleaux (fig. 65), as when a drop of fresh blood unmixed with urine is examined.

If the blood is present in smaller quantity, or even if

copious, but more slowly effused, all traces of the linear arrangement of the corpuscles is lost, and they are found separate and floating in the fluid (fig. 66). On first examining the object, the corpuscles resemble little rings; an optical illusion arising from their being nearly emptied of their contents by exosmosis. The corpuscle thus becoming a doubly concave disc, a change which receives a ready explanation by the very interesting demonstration of the real structure of the corpuscles by Dr. Rees.[90] Sometimes an appearance of a spiral fibre, like that described by Dr. Martin Barry[91], is observed.


Fig. 65.

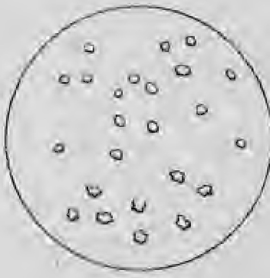
Fig. 66.

This appearance of the supposed fibre has always appeared to me to be an optical delusion arising from the delicate investing membrane of the nearly empty corpuscle collapsing in circular folds round the nucleus, as a centre. By longer repose in urine, the corpuscles alter still further in figure, becoming irregular at their margins, as is shown in part of fig. 66.*

* The blood-casts which in many cases of hæmaturia are found in the urine have been already noticed, in connection with the subject of renal casts. They are generally hyaline or structureless casts, entangling in their passage downwards the corpuscles of the blood.

Whatever are the modifications presented by the blood-corpuscles in urine, their non-granular surface, uniform size, and yellow colour under the microscope, will always be sufficient to identify them.

322. *Pathological indications.* — Whenever the elements of blood appear in the urine, there is ample proof of the existence of active or passive hæmorrhage. If, however, the quantity of hæmatosine be so minute as barely to tint the urine, it is probable that the albumen present may be really secreted (*i. e.*, without breach of surface) by the kidney assuming an abnormal function. This is probably the case in the peculiar disease of the kidney so laboriously and successfully elucidated by Dr. Bright, the effusion of albumen being, in the first stage of the disease, an attempt to relieve a congested condition of the kidney, and must be regarded as an effort of diseased function; whilst the structural changes which afterwards occur, unfit the kidneys for eliminating the normal nitrogenized elements of urine, and the chief relict of its secreting power is found in the separation of water and albumen from the blood. On the recession of some affections, in which the cutaneous function is temporarily impaired or suspended, especially in scarlatina, a congested kidney occurs as an almost necessary result, and albuminous urine results as in the first stage of morbus Brightii. During the existence of pregnancy, and perhaps of some pelvic tumours, the urine is occasionally and temporarily albuminous; a fact first noticed by my colleague Dr. Lever,[92] and meeting with a probable explanation from the possible existence of pressure on the emulgent veins, a condition which the researches of Dr. Robinson[92] have shown to be capable of producing congestion of the kidney and serous urine.

Where blood is present in large quantity, or coagula are mixed with the urine, hæmorrhage from some breach

of surface is indicated; and the immediate cause of this, whether a ruptured vessel from excessive congestion in any part of the urinary organs, the irritation of a calculus, mechanical violence, or malignant disease, as fungoid degeneration,* can alone be made out by a careful examination of the existing symptoms.

323. *Therapeutical indications.*—These will vary according to the immediate cause producing the sanguineous or albuminous effusion. Of course, where active hæmorrhage exists, the treatment will be directed by the view taken by the practitioner of its immediate exciting causes. Absolute rest, the local application of cold to the hips and loins, the relief of congestion of the kidneys by local or general blood-letting, free action on the bowels by saline (sedative) purgatives, with dilute acids, will constitute the essential part of the therapeutic agents. The administration of the acetate of lead is frequently of great service, but it should be administered boldly, and in tolerably large doses, for a *short* time; a plan far more effectual than that generally followed, of giving small doses for a longer period. In doses of three or four grains, with one fourth of a grain of opium in a pill, repeated every two hours until six or eight doses are taken, this remedy is very successful. I, however, prefer administering the lead in solution; in this form it is readily taken by the patient, and seems to act most efficiently, as in the following formula:

℞ Plumbi acetatis, gr. xxiv;
Aceti destillati, f℈j;
Syrupi papaveris, f℥j;
Aquæ rosæ, f℥iij;
Aquæ destillatæ, f℥iv. M. fiat mistura.
Cujus sumat æger coch. ij magna omni secundâ horâ.

* The source may mostly, in these cases, be determined by the appearance of compound cells when the urine is placed under the microscope.

If care be taken to keep the bowels acting by a saline purgative, no fear of any unpleasant consequences from the lead need be apprehended during the period required to give it a fair trial. The gums should, however, be watched, and if the blue edge described by the late Dr. Burton[94] be seen, the medicine must be at once given up.

324. No remedy has, however, appeared to me to be of such extraordinary value in the treatment of hæmaturia, as gallic acid. I have seen this drug arrest for many weeks bleeding from an enlarged and (fungoid?) kidney, after all other remedies had failed. It should be given in doses of at least five grains in a draught, with mucilage, and a little tinct. hyoscyami, and repeated at short intervals. This drug really acts as a direct astringent, reaching the capillaries of the kidney, and finding its way into the urine, which soon becomes so impregnated with it as to be changed into ink on the addition of a few drops of tinctura ferri sesqui-chloridi.

I believe it to be very important to take every precaution that tannic acid or tannin is not substituted for gallic acid. Closely allied as these bodies are, and readily as the former is converted into the latter, merely by a few hours' exposure of its solution to the air, still there is great reason to believe that tannin is never absorbed as such into the circulation. Professor Mülder[182] has explained this on the power it possesses of coagulating albumen, and hence, unless it undergoes some previous change, it cannot possibly circulate in the blood, as it would immediately coagulate it. Mülder has declared his belief that if the astringent matter present in two ounces of cinchona bark could, by any possibility, be absorbed into the blood, it would, in this manner, produce instant death.

325. When the only constituent of blood present in the urine is albumen, the treatment will vary according to whether the kidney is merely congested or structurally affected. The treatment of the latter class of cases has been fully detailed elsewhere,[95] so that it is unnecessary for me to give any account of it. The treatment of the acute stage of congested kidney, occurring in children in the dropsy after scarlet fever, when the urine is albuminous, and dingy from the presence of red particles, is, in the great majority of cases, so successful and uncomplicated, that it is important to allude to it.*

I may remark, as a prophylactic remedy, that the

* In the chronic stages of the various phases of disease known as Bright's disease, as in the acute stages, the point of first importance is attention to the skin and the secretion generally, avoiding, if possible, mercurials and diuretics. The accumulated experience of many years has shown that patients cannot bear the operation of mercury; in some cases, indeed, the smallest quantity, even a couple of grains of blue pill, has produced violent and dangerous salivation. And I think that I may also state that general experience is equally against the use of diuretics. In the early stages the tubes are blocked up by disintegrated epithelium, and the blood is already overcharged with a diuretic in the shape of the retained urea, which in the latter stages, on the removal of the obstruction, renders the use of any other diuretic unnecessary. I am not unaware that the treatment by diuretics has been advocated by Dr. Burrows; but the pathology of the disease, as at present understood, certainly contra-indicates their use, and the more rational course of treatment is attended with such a degree of success as to disincline me to run the risk of recommending remedies which may be either dangerous or unnecessary. The measures best adapted to restore and preserve the functions of the skin are—warm baths, flannel-clothing, and antimony; while the compound jalap-powder, with or without elaterium, in doses for the adult of two scruples of the powder, with one sixth of a grain of elaterium, is the most effectual remedy for relieving the bowels. When the kidneys begin to act, as shown by the increased secretion of the urine, and the skin is perspirable, chalybeates are indicated; and I have myself found the tincture of the sesquichloride of iron, in doses of fifteen minims, with or without an equal quantity of tincture of henbane, the best mode of prescribing them.

warm bath is invaluable; I scarcely recollect, even in a large experience, a case of dropsy after scarlet fever occurring, when the warm bath was daily used as soon as the skin began to exfoliate, and continued until a perspiring healthy surface was obtained. When anasarca has occurred, strict confinement to bed, or at least to a warm room, must be enjoined, the warm bath used twice a week, and a free action on the skin encouraged. The bowels should be kept acting by the pulvis jalapæ compositus, and the antimonii potassio-tartras administered in doses varying from one twelfth to one eighth of a grain, four or five times in the twenty-four hours, according to the age and strength of the patient. A bland and nearly fluid but moderately nutritious diet should be enjoined. This plan must be continued until all anasarca has vanished, a supple and perspiring surface obtained, and urine free from albumen. The remedies may then be gradually left off, a more nutritious diet allowed, and the ammonio-citrate of iron administered thrice daily, in doses of three to five grains, to remove the anæmiated state of the patient. On leaving the bed-room, a flannel-waistcoat, extending to the loins, should be worn for some time. This treatment has been almost invariably successful in every case I have employed it, and I may remark that I have never in these cases witnessed the excessive prostration said by some to be the almost necessary result of the employment of antimony in the diseases of children.

326. I cannot too anxiously caution the practitioner against the employment of the still too generally used diuretics in these cases. A more mischievous practice can hardly be employed, for on the recession of scarlatina the lining membrane of the tubuli is often left inflamed, the tubules themselves

being obstructed by an abundance of desquamatory epithelium. The necessary effect of stimulating diuretics is to determine blood towards already oppressed kidneys; to injure organs, moreover, whose important depurating offices are so necessary to the continuance of life, and the integrity of which diminishes as congestion increases. Bloody urine, the non-elimination of effete nitrogenized elements from the blood, and death by convulsions, have repeatedly resulted from this most serious error.*

PURULENT DEPOSITS.

827. Pus is not unfrequently met with in the urine, as the result of suppuration of the kidney, or of some portion of the genito-urinary mucous membrane, or of abscesses from adjoining viscera or abnormal growths, bursting into the urinary cavities. There is said also to be occasionally another source of purulent matter in the urine, viz., when a vicarious discharge of pus occurs from the kidneys. Many pathologists, especially in Germany, have declared their belief in the frequent occurrence of this phenomenon, and cases have been recorded of empyema disappearing contemporaneously with the discharge of purulent urine. The subject is, however, still obscure, and any opinion must in the present state of our knowledge be given with caution (330).

At present, however, there does not exist a single satisfactory proof that bodies, the size of pus-particles, can ever enter or escape through the walls of capillary vessels without breach of structure. In all cases where

* See note, p. 358.

a purulent deposit is really absorbed into the circulation, independently of breach of surface, it is, in all probability, first metamorphosed into soluble products.

328. *Characters of urine containing pus.*—Generally acid or neutral, unless long kept, and slow to assume putrefactive change. By repose, pus falls to the bottom, forming a dense homogeneous layer of a pale greenish cream colour, never hanging in ropes in the fluid like mucus (unless the urine is alkaline), and becoming by agitation uniformly diffused through it. The addition of acetic acid neither prevents this diffusion, nor dissolves the deposit. If a portion of the deposited pus be agitated with an equal quantity of liquor potassæ, it forms a dense translucent gelatinous or mucous mass, often so solid that the tube can be inverted without any escaping. On decanting some urine from the deposited pus, the presence of albumen can be detected by heat and nitric acid (317). When pus is agitated with ether, a quantity of fat is dissolved, which is left in the form of yellow butter-like globules, when the ether is allowed to evaporate in a watch-glass. The peculiar action of liquor potassæ, coupled with the albuminous state of the urine, constitute the best test for the detection of pus.

If the urine containing pus happen to be alkaline and to contain free ammonia, the character of the deposit is completely altered, becoming viscid, not readily diffused by agitation through the fluid, and resembles in appearance some varieties of mucous deposits. The detection of albumen in the supernatant fluid by the addition of nitric acid, and the conversion of the deposit into a white granular mass, destitute of its previous viscidity by the addition of acetic acid, will generally enable a safe opinion as to the nature of the deposit to

be arrived at. A source of fallacy may occur in the urine of women, which may be supposed to contain pus, merely from an admixture of leucorrhœal or other vaginal discharges. In such specimens, traces of albumen can generally be detected in the urine, whilst the deposit, instead of presenting the dense homogeneous layer so characteristic of pus, is flocculent and granular, although often extremely copious, and readily gelatinizing with liquor potassæ.

329. *Microscopic characters of pus.*—This substance consists essentially of round granules, or particles rather larger than blood-corpuscles, floating in an albuminous fluid, or *liquor puris*, differing essentially from *liquor sanguinis*, in the absence of a spontaneously coagulating power. When a drop of a purulent fluid is placed under the microscope, the particles become visible; they are white, roughly granular exteriorly, and are much more opaque than blood-corpuscles (fig. 67, *a*). On the addition of a drop of acetic acid, the interior of the particle becomes visible, and is found to be filled with several transparent bodies or nuclei, as shown in the figure *b*. Hence pus is usually considered as a regularly organized body, consisting of a granular membrane enveloping transparent nuclei; being in fact a nucleated cell. The microscopic examination of a suspected purulent deposit is essential, for, as we have seen, phosphatic sediments will sometimes so closely resemble pus, as to deceive a practised eye (259).*

Fig. 67.

* Pus-casts have been already noticed.

330. *Pathological indications.*—Whenever pus occurs in urine, it generally indicates the existence of suppurative inflammation in some part of the urinary apparatus. It must, however, never be forgotten that an abscess from any adjoining viscus, may discharge its contents by an ulcerated opening into the pelvis of a kidney or into the bladder. Suppuration in a more distant organ, will often, by burrowing under the peritoneum or through muscles, be discharged by the urinary apparatus. An empyema has thus been known to find its way to the kidney, emptying itself through an ulcerated opening, and be discharged with the urine. This is in all probability the mode in which the purulent contents of a diseased pleura have escaped, in the supposed cases of metastatic discharges of pus from the kidney, which have been repeatedly published on the Continent (327).

The therapeutical indications of purulent urine will, of course, strictly depend upon the nature of the disease under which the patient labours, and the source of the suppuration.

MUCUS.

331. The quantity of mucus present in healthy urine is very small, being merely sufficient to form a barely visible cloud. When collected on a filter it dries, forming a thin varnish-like layer.

Characters of urine containing an abnormal proportion of mucus.—The quantity of mucus in urine may vary under the influence of different degrees of irritation or inflammation, from a mere flocculent cloud to the production of a fluid so viscid and tenacious, as to be capable of being poured from one vessel to another in a long continuous rope.

Urine containing a deposit of mucus is generally

alkaline, and soon undergoes a putrefactive change, becoming ammoniacal even in the bladder, if long retained. If the urine itself be acid when first voided, the mucus it deposits will always restore the blue colour of reddened litmus. Thus a specimen of urine will frequently redden litmus-paper, and the blue colour will be restored by allowing it to sink into the mucous deposit at the bottom of the vessel.

Indeed, as a general rule, all mucous secretions exert an alkaline action on faintly reddened litmus-paper, a condition which becomes better marked under the influence of inflammatory action, however slight. In common cynanche tonsillaris, in which the compound infusion of roses is often used as a gargle, nothing is more common than to observe the red mixture ejected from the mouth quite green, the white fur on the tongue presenting a similar colour, the quantity of alkali in the mucus covering the fauces and tongue, being sufficient to neutralize the sulphuric acid, and to change the red colour of the roses to green.

Providing the urine is even slightly acid, a deposit of pus and mucus may be readily distinguished, as the former will appear as a homogeneous opaque layer, readily miscible by agitation with the urine; whilst the latter will appear gelatinous, and hang in irregular masses, often entangling large air-bubbles, and no agitation, however violent, can completely mix it with the urine. There can never be any difficulty is distinguishing between purulent and mucous deposits by simple inspection, unless the urine be alkaline (264); or a large quantity of earthy phosphates (262) be mixed with the mucus, which thus acquires great opacity, and may be readily mistaken for pus without microscopic examination.

332. The action of acetic acid on mucus is very characteristic, and is of great value in discriminating between that fluid and pus. When a fluid containing the former is mixed with acetic acid, the fluid part of the mucus in which the particles float, coagulates into a thin semi-opaque corrugated membrane, presenting an appearance so peculiar that once seen it can never be mistaken.

Mucus contains no albumen in a state allowing of coagulation by heat or nitric acid (317); hence simply mucous urine can never be albuminous like pus unless the albumen be derived from some other source.

Agitated with ether, mucus gives up but mere traces of fat, and in this respect also differs from pus.

333. *Microscopic characters of mucus.*—Mucus, like pus, is composed of granular round particles, floating in a fluid, which is viscid and glairy, and does not contain uncombined albumen. Under the microscope, it is nearly, if not quite, impossible to distinguish between the pus and mucous particles—in fact, it may be questioned whether they are not identical.* Where mucus and pus essentially differ is not so much in the nature of the particles as in the fluid secreted with them, and in which they float; the *liquor puris* being albuminous and coagulable by heat (328), the *liquor muci* not being affected by it. Treated with acetic acid, the mucous particle exhibits internal nuclei similar to those seen in pus (329). The particles are by no means so numerous as in the latter, and are perhaps not so distinctly granular; a rather higher magnifying power being required to show satisfactorily the granular surface of the mucus, than of the pus particle. Even this slight dis-

* They are really identical, both being secreted by a membrane in a state of inflammation.

tinction may depend rather upon the greater refractive power of the fluid part of the mucus, concealing the irregularities on the surface of the mucous particle from ready observation, than upon any real difference between them.

334. *Pathological indications of mucous deposits.*—Their general indication, that of an irritated or inflamed state of the genito-urinary mucous membrane, which may be excited by a variety of causes. Independently of *idiopathic* acute or chronic cystitis, certainly rare affections, the mucus may be the result of the disease termed cystorrhœa, probably really a low form of chronic inflammatory action, in which a large quantity of secretion is poured out from the mucous membrane of the bladder, and gives great distress by producing much irritability of the viscus, and interfering with the free flow of urine. Mucous deposits are more generally symptomatic of some mechanical cause irritating the vesical mucous membrane, as the presence of a calculus, or the existence of a stricture in the urethra, or of some other mechanical obstruction to the free escape of urine. Cystorrhœa, accompanied by a copious secretion of phosphates by the vesical mucous membrane, has been already alluded to (296).

335. *The treatment of mucous urine* must strictly depend upon the nature of the exciting cause. It can never be treated as a special affection, except perhaps in cases of cystorrhœa or chronic cystitis, when much advantage is gained by the employment of certain remedies which are supposed to exert a specific action over the secreting function of the mucous membrane of the bladder. This specific action, after all, generally depends upon the astringent element of the drug reaching the urine, and thus acting nearly as directly

as an injection of alum into the vagina does in leucorrhœa. Most of the vegetable astringents containing gallic acid are here available, but some have obtained a more especial reputation, from their containing some elements which enable them to fulfil more than one indication, and hence become applicable in particular cases. Among these, the leaves of the arctostaphylos uva ursi, barosma crenata or buchu; chimaphila umbellata, and root of the pareira brava, are the most celebrated. Although these are often prescribed, as if they all acted in the same manner, in checking the excessive mucous secretion, yet each fulfils a second indication which never should be lost sight of. Thus we find in the—

> Uva ursi, a simple astringent, but slightly diuretic.
>
> Chimaphila, a less active astringent, but freely stimulating the kidneys.
>
> Buchu, a stimulating tonic, diuretic, and diaphoretic; whose active principle (volatile oil) is excreted by the kidneys.
>
> Pareira, a narcotic (?) tonic diuretic.

336. When a microscopic examination of the mucus has shown that an excessive elimination of phosphates does not exist, the irritability of bladder and cystorrhœa are remarkably relieved by the administration of alkalies, especially of the bicarbonate of potass (℈j) or liquor potassæ (♏xx—ʒj) with a sedative, as tinct. hyosciami (ʒss), in an infusion or decoction of one or other of the above drugs. When the earthy salts are copiously excreted, the dilute phosphoric acid (ʒss) may be advantageously substituted for the alkalies. Although it must not be supposed that the presence of a moderate quantity of phosphatic deposit with the mucus necessarily contra-

indicates the administration of alkalies. We have already seen that the alkaline state of urine and deposition of earthy salts is a result of the action of unhealthy mucus, secreted by the bladder, upon the urine (275). When the administration of alkalies is capable of controlling the secretion of mucus, these remedies will lessen and even remove the earthy deposits instead of increasing them, by checking the formation of the substance which induced their precipitation. In several cases, I have seen marked relief follow the use of benzoic acid (gr. ix) given in dec. parciræ (℥iss), with a minute dose of acetate of morphia (gr. $\frac{1}{6}$—$\frac{1}{4}$). In one very severe case, which was for some time under the joint care of my colleague, Mr. Cock, and myself, in which such an enormous quantity of alkaline purulent mucus was secreted from a chronically inflamed bladder, that micturition was often quite prevented, from the urethra becoming temporarily blocked up with the secretion, so much temporary relief was afforded by this medicine that the patient declared he could not make water without it.

The parcira indeed, as remarked by a high authority, Sir Benjamin Brodie,[97] is of the greatest use, where the mucus is copious and opaque, and the distress of the patient, from a constant desire to empty the bladder, considerable. In mild cases, where the normal character of the mucus is scarcely changed, we may employ the uva ursi; the chimaphila being preferred if the kidneys are inactive. The buchu, from its free action on the skin, being of most service where a highly irritable state of kidney or bladder exists.

337. I cannot avoid alluding here to the very great advantage resulting from freely washing out the bladder with warm water in these cases as well as in phosphatic urine (297). By this treatment all the alkaline urine

and portions of mucus generally left behind are washed out, and the bladder is placed in a much more satisfactory condition. The relief even temporarily given to the patient by injecting the bladder with warm water is so great, as to justify its frequent use even in cases where the mucous membrane is so extensively diseased as to preclude all hope of ultimate recovery.

I have found it of peculiar value in the treatment of cystorrhœa following lithotrity. In a very interesting case, which I recently saw with Mr. Hodgson, the irritability of bladder and secretion of mucus nearly ceased, after a few injections of warm water.

Even in these most hopeless cases, paralysis of bladder from spinal paraplegia depending upon incurable disease of the spine, the relief obtained by this remedy is most remarkable. The comfort of the patient and of his attendant is not a little increased by the disappearance of the fœtid urinous odour, which is too generally a serious source of annoyance.

ORGANIC OR EXUDATION GLOBULES.

338. There are two other forms of globules allied to mucus occasionally found in urine, which, for want of a better name, and until their true pathological relations are better understood, I proposed to name *organic globules*. *The large organic globule* much resembles the mucus particle or globule, being composed of a granular membrane investing a series of transparent nuclei, which become visible on the addition of acetic acid. In some, two nuclei of a crescentic shape, with their concavities opposed, are alone seen. I know of no character by which these bodies can be distinguished from pus or mucus, excepting that they are unaccompanied by the

characteristic albuminous or glairy fluids (333) in which the pus and mucus particles respectively float. The large organic globules seldom form a visible deposit, being free and floating in the urine, and are generally so scattered that not more than a dozen or two are visible at one time in the field of the microscope. They are abundant in the urine of pregnant women, especially in the latter months, when there is a frequent desire to empty the bladder. They have existed in every case of ardor urinæ I have examined, although irritability of bladder was not *necessarily present*, but when this does exist they abound. The globule under consideration occurs in the greatest abundance in the albuminous urine of confirmed morbus Brightii. I have seen them so abundant as to cause a drop of the urine to resemble, when microscopically examined, diluted pus, a resemblance rendered more close by the albuminous character of the urine. Is it possible that these globules may here be indicative of subacute inflammatory action going on in the structure of the kidney? I am not aware whether they are quite identical with what have been termed the exudation or inflammatory globules of Gluge. The marginal figure, copied from one by Simon in his 'Beitrage,' accurately shows the common microscopic appearance of deposits in the urine of morbus Brightii. The large dark bodies are organic globules; mixed with them are seen altered blood-discs and epithelial cells, the latter, as shown from some late researches of Dr. G. Johnson, frequently containing globules of fat (368), whilst a tubular mass of coagulated

Fig. 68.

albumen, probably the cast of a uriniferous tubule (319), entangling granules and blood-discs, occupies the centre of the figure.*

339. In a most distressing class of cases which occasionally occur in practice, where all the symptoms of stone in the bladder exist, without any calculus being present, these globules are almost invariably present. This is more especially the case when a roughened state of the interior walls of the bladder can be detected by the sound. A more intractable and distressing ailment hardly exists. I may add a remark of some practical interest, that it has occurred to me to meet with a case in which the operation for lithotomy was performed, but no stone found; the result was, that the patient consequently lost the symptoms which had distressed him for years. My colleague, Mr. Bransby Cooper, has mentioned to me a similar case.

340. *The small organic globules* are very beautiful microscopic objects. These little bodies are very much smaller than the pus or mucus-particles, and are essentially distinguished from them by the absolute smoothness of their exterior, no trace of granulation being visible even with a high magnifying power. I have never been able to detect a nucleus, or any other sign of definite structure, except their well-defined figure. In hot acetic acid they are quite unchanged. On the slightest agitation they roll over each other with the utmost facility, which their perfectly spherical figure readily permits.

These globules form a visible white deposit, resembling, to the naked eye, a sediment of oxalate of lime.

So rare are these curious little bodies, that compara-

* These bodies are probably what Henle called cystoid corpuscles, which occur in lymph, as lymph-corpuscles; in the blood, as colourless blood-cells; in the mucus of the mucous membranes, as mucus-corpuscles. (Lehmann.)

tively few examples of them have occurred to me; in two, the urine was passed by women during menstruation. It is just possible that they may really be nuclei of some larger nucleated cell, as pus or mucus, and have escaped by the bursting of the investing membrane or sac of the cell.*

EPITHELIUM.

341. The epithelial covering of the genito-urinary mucous membrane is, like the external skin, constantly experiencing the effects of wear and tear, causing a more or less rapid exfoliation of epithelial cells. This

* Dr. Hassall has observed another kind of organic globule in several cases of catarrhus vesicæ, and also in simple irritation of the mucous membrane of the bladder, the consequence of enlarged prostate or other cause, and accompanied with an increased discharge of mucus. They vary in size, are circular, and many times larger than pus- or mucus-corpuscles, and contain very distinct granular nuclei, clearly defined without the aid of acetic acid or other reagent. The number of these nuclei is often very considerable, and are themselves almost as large as ordinary mucus- or pus-corpuscles.

Fig. 69.

Large compound globules from a case of catarrhus vesicæ with enlarged prostate.—Copied from Dr. Hassall's paper in the 'British and Foreign Medico-Chirurgical Review' for July, 1853.

structure is sometimes partly broken up, so as to appear like patches of membrane-like mucus, and its cells are irregularly lacerated. Most generally, however, a certain number are entire, and can be readily recognised by their microscopic characters; when distended with fluid they are regularly oval cells, becoming irregularly angular and flattened when partially empty. When they are quite empty a well-marked central nucleus often appearing, if the focus be not properly adjusted, to project like the central boss of a shield (fig. 70,) is seen in each. These cells sometimes contain fat-globules, and when existing in any quantity, have been stated to be pathognomonic of some varieties of morbus Brightii (369).* The exfoliation


Fig. 70.

* Fig. 71, representing the epithelium of the pelvis of the kidney, is taken from Kolliker's work, translated for the Sydenham Society. The epithelium is thick, measuring from 0·02—0·04''' Paris lines, or ·0017—·0035 English


Fig. 71.

of epithelium sometimes is very considerable, so as to give rise to a copious deposit in the urine which to the naked eye resembles mucus: but may be readily distinguished by the absence of all viscid qualities. Mixed with liquor potassæ, such urine gelatinizes nearly as perfectly as when pus is present. When oxalate of lime exists in the urine, an abundance of epithelium is generally found, and indeed has often, from its presence, induced me to make a careful investigation for the detection of that salt (230).

SPERMATOZOA.

342. Spermatozoa, the so-called spermatic animalcules are by no means very unfrequent in urinary deposits; a few being occasionally found on examining microscopically the inferior portions of the urine of the male adult, after allowing it to repose for some time in a glass vessel. In some cases, however, a sufficient quantity of spermatic fluid is found mixed with the urine to form a visible cloud, and becomes an important guide to the practi-

inches, is laminated, and characterised by the variety of form and size of its elements, of which the most deeply seated also are rounded and small, and those in the middle cylindrical or conical.

It is a striking fact that the cells frequently contain two nuclei, as well as clear, darkish-coloured, round granules, measuring ·0008—·0017 English inches. The epithelial cells of the convoluted tubes have been alluded to. The epithelium of the bladder is both columnar and scaly; the former lines the mucous follicles, while the latter covers the general surface of the membrane. In the fundus the columnar epithelium is mixed with large oval cells. The urethral epithelium is mostly columnar, becoming scaly towards the orifice. The vaginal epithelium consists of large cells of the pavement variety. The different forms are well figured in Dr. Lionel Beale's work on the Microscope.

tioner, in the investigation of a case perhaps previously obscure.

Diagnosis of spermatic urine.—If a small quantity of spermatic fluid is present in urine, it may easily be passed over and mistaken for mucus, from which there is no character, independent of microscopic examination, capable of distinguishing it. If, however, we have a specimen of urine passed by a man which is cloudy and opalescent, reddens litmus paper, and does not become clear on the application of heat or nitric acid, the presence of spermatic fluid may be at least suspected, especially if the characteristic odour of that secretion be perceptible. Should a larger quantity of the secretion be present, it subsides to the bottom of the vessel, and may be recognised by its physical character. If mere traces of spermatic liquor only are mixed with urine, they may easily be detected by violently agitating the urine, and allowing it to repose in a conical glass vessel for a few hours. On carefully decanting all the urine except the last few drops, the spermatozoa may be detected in the latter by the microscope. The addition of nitric acid will often produce a slight troubling in this urine. M. Lallemand[106] describes spermatic urine as opaque and thick, as if mixed with gruel, with a fetid and nauseous odour; characters sufficiently common in ammoniacal urine (212,) but certainly by no means, at least in this country, necessarily or generally characteristic of urine containing spermatozoa. In fact, an abundance of these little organisms may be present, without modifying materially the physical characters of the urine.

343. *Microscopic characters of spermatic urine.*—No character can be assumed as distinctly diagnostic of the presence of semen in the urine, except the discovery of the spermatozoa. These minute structures never

occur living in urine, unless protected by the presence of a deposit of pus, in which they retain their power of moving for a long period after emission. Urine appears to be immediately fatal to their vitality, but exerts no further action upon them, as they may be detected scarcely changed even after it has become ammoniacal. An object-glass, of one fifth or of one eighth of an inch focus, should be used for the detection of these minute bodies. The drop of urine chosen for examination should be taken from the bottom of the containing vessel, placed on a slip of glass, and covered with a piece of mica or thin glass. The spermatozoa will be observed as minute ovate bodies, provided with a delicate bristle-like tail, which becomes more distinct on allowing the drop of urine to dry on the glass (fig. 72). Mixed with these are generally found round granular bodies, rather larger than the body of a spermatozoon, and nearly opaque from the numerous asperities on the surface of the investing membranes? These appear to be identical with the seminal granules described by Wagner[107] and others.

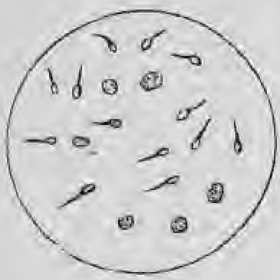

Fig. 72.

344. Well-defined and often large octohedra of oxalate of lime (214) are of common occurrence in spermatic urine. The connection of this saline body with the presence of spermatozoa was first pointed out to me in a private communication with which I was favoured by Professor Wolff, of Bonn. Very lately M. Donne has stated, as the result of his observations, that they frequently occur together, and that the presence of

oxalate of lime is a constant indication of the existence of spermatorrhœa. This statement is quite opposed to my own experience, for although in the latter disease oxalate of lime often exists, yet this salt constantly occurs where no suspicion of an escape of semen can be entertained (248).

345. *Pathological indications.*—Whenever spermatozoa, or spermatic granules are detected in the urine, it is quite certain that the seminal secretion must have been mixed with it. The causes of this admixture are numerous, for it must be recollected that if the bladder be emptied even some time after a seminal emission, a sufficient number of spermatozoa will remain in the urethra to be washed away with the urine, and cause it to assume the ordinary microscopic character. A certainly not unfrequent cause of the escape of semen is extreme constipation, for after the passage of hard and scybalous fæces, an oozing of fluid from the urethra, full of spermatozoa, is not uncommon. In some cases of stricture of the urethra, anterior to the orifices of the seminal ducts, an accumulation of semen may, upon sexual excitement, collect, and, flowing into the bladder, be voided subsequently with the urine. An admixture of semen with the urine may occur occasionally in paraplegia, in persons reduced in health by excessive indulgence in intercourse, or by even less creditable modes of producing excitement of the sexual organs.

346. *Therapeutical indications.*—The irritable state of the nervous system, the depressed general health, and in some cases the appearance of epilepsy, or of symptoms not unlike mild forms of delirium tremens, and characterised by the most abject melancholy and despondency, are familiar to all, as the effects of the too copious and frequent excretion of seminal fluid,

whether excited or involuntary. To this ailment, spermatorrhœa, as it has been named, great attention has been drawn especially by M. Lalleland, and by several writers in the English medical journals. That the detection of spermatozoa in the urine will often enable the physician to detect a source of exhaustion previously concealed from him, and baffling his treatment, is unquestionable; but that this matter really merits all the verbose attention lately lavished upon it, is not so evident. I am quite sure that very great mischief has resulted by the publicity given to the reported results of spermatorrhœa, in the moral effects produced on weak-minded young men who too generally read these reports with avidity; no less than in the encouragement given to a most atrocious class of quacks and empirics.

I hardly know any state of mind more difficult to treat than that which is so often present in patients who believe themselves to be the subjects of spermatorrhœa. Although, perhaps, there may be no reason to believe that losses of this kind are actually going on, the patient's mind is too generally made wretched, and his happiness blasted, by the iniquitous pictures drawn of the presumed results of spermatorrhœa by the miserable harpies who have so generally taken possession of this department of practice, and acquire the strongest hold over their victims by the threats and promises they alternately hold out. The patient's mind is so poisoned by the tales of misery and wretchedness poured into his ears by these persons, that it is often impossible to excite any hope of recovery, and they seem, indeed, to regard their imaginary impending fate with a sort of gloomy satisfaction.

347. In the treatment of spermatorrhœa it appears necessary to examine the therapeutic means to be em-

ployed in two points of view; as curative of the involuntary discharge, and of the habits keeping it up. The first indication is best fulfilled by attending to the general health, by cold hip-baths, or by dashing cold water over the genitals; by the use of astringent injections into the urethra, or the application of solid nitrate of silver to that part of the canal where the seminal ducts open, as recommended by Lallemand and Mr. B. Phillips. I may be permitted, however, to enter a strong protest against the reckless employment of this remedy. In the hands of experienced surgeons no injury is likely to follow its use, but unhappily this mode of practice has been adopted by the helots of our profession to whom I have before alluded. I have seen the most distressing results follow the use of the local application of the lunar caustic in the treatment of presumed spermatorrhœa. As an example, I had under my care a case of intense cystitis occurring in the person of a previously healthy young farmer, who, being about to be married, began to be anxious on account of his observing an involuntary emission once in five or six weeks. His attention was arrested by one of the advertisements which too often disgrace our daily papers. He came up to town, consulted the quack, whose name he had then discovered. He was declared to be impotent—the nitrate of silver was applied, and the result was cystitis, which placed his life in peril. The use of iron, persisted in for some time, with a little quinine, and a careful use of purgatives, will greatly expedite the recovery of the patient. Marriage also becomes a very important curative agent. The second indication is fulfilled by an influence on the moral feelings of the person, and if these have no effect, the application of a blister, or croton oil, to the prepuce, or in some cases circum-

cision, will be found available in breaking through an iniquitous and injurious habit.

CONFERVOID GROWTHS.

A. *Torulæ Cerevisiæ.*

348. It is well known that in all saccharine fluids undergoing the alcoholic fermentations, minute confervoid, or fungoid vegetations (to which M. Turpin gave the name of *Torula cerevisiæ*) appear, and pass through certain definite stages of development. There is, indeed, considerable reason to believe that these vegetations, to a certain extent, bear to fermentation the relation of cause and effect. The arguments lately advanced by Professor Liebig, in opposition to this opinion, do not, to my mind, afford a satisfactory answer to the observations previously made on this subject.

When urine contains but very small portions of sugar, too little even to affect its specific gravity materially, or to cause it to assume a diabetic character, certain phenomena are developed connected with the production of the vegetation of the genus Torula or Saccharomyces, which will at once point out the presence of sugar. These indications are of very great value as a guide to our treatment, as an occasional saccharine condition of the urine is, according to recent statements, not uncommon in some forms of dyspepsia in old age, when the health begins to give way.

349. When saccharine urine is left in a warm place, a scum soon forms on its surface, as if a little flour had been dusted upon it. This consists of minute oval bodies which soon enlarge from the development of

minute granules visible in their interior. These continue expanding, and dilate the oval vesicle containing them into a tubular form; soon afterwards the internal granules become larger and transparent, and project from the exterior of the parent vesicle like buds. The whole then resembles a jointed fungoid or confervoid growth, which ultimately breaks up; and a copious deposit of oval vesicles or spores fall to the bottom. All these stages of development (Fig. 73) require but a few hours for their completion. If the deposited spores be placed in a solution of sugar, they rapidly germinate, and, exciting fermentation, produce a new crop of torulæ. During the growth of the torulæ, bubbles of carbonic acid gas are evolved, and the urine at length acquires a vinous odour, generally accompanied by that of butyric acid. There are two kinds of urine which may be mistaken for saccharine, by the occurrence of a kind of fermentation, not unlike that of fluids really containing sugar. I refer to the form of viscous[108] fermentation which occurs in urine and ending in the appearance of much ropy mucus. This has occurred to me repeatedly in specimens of urine containing cystine, the odour evolved being, however, disagreeable and sulphureous, quite distinct from the vinous odour of the alcoholic fermentation. Somewhat similar phenomena are occasionally presented by the urine of persons exhausted in health from scrofulous or syphilitic cachexia.*

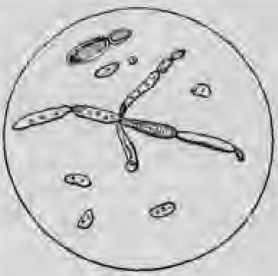

Fig. 73.

* The two plates (fig. 74 and 75) represent the growth of the torula;

350. Saccharine urine cannot be distinguished, by its appearance, from normal urine. Its specific gravity is generally high, and in consequence it becomes frothy on agitation; its colour is pale, its odour fragrant, and its taste sweet. It is also generally transparent. The presence of sugar, however, once suspected, may be easily proved by analysis or the application of tests.[100] If a moderate quantity of sugar exists, the urine may be evaporated to an extract and digested in hot alcohol; when cold, the tincture should be decanted and allowed to evaporate spontaneously in a cylindrical vessel (a cupping-glass answers very well). In this way white granular masses of sugar will crystallize on the sides of the glass, whilst if the evaporation be expedited by heat, crystals are obtained with great difficulty, and often not

the first (fig. 74) is taken from Dr. Lionel Beale's work on the Microscope, and the latter from Dr. Otto Funke's beautiful Atlas; *a, a*, shows the first or

Fig. 74.

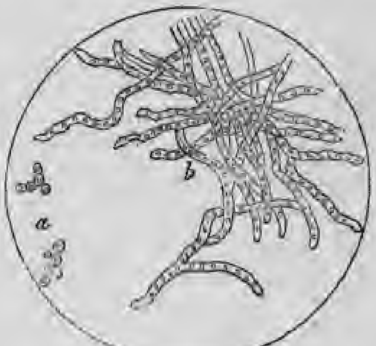

Fig. 75.

vesicular form; fig. 74, *b*, the germination, and fig. 75, *b*, the appearance assumed about the eighth day.

at all, until the urea and other organic ingredients have been got rid of by a tedious process.

351. The most trustworthy tests for the detection of sugar in urine depend for their action upon the reducing action of sugar on salts of copper, or upon the decomposition of the sugar by alkalies.

A. *Trommer's Test.*—Add to the suspected urine in a large test-tube just enough of a solution of sulphate of copper to communicate a faint blue tint. A slight deposit of phosphate of copper generally falls. Liquor potassæ must then be added in *great excess;* a precipitate of hydrated oxide of copper first falls, which *redissolves in excess of alkali* if sugar be present; forming a blue solution like ammoniuret of copper. On gently heating the mixture to ebullition, a deposit of red suboxide of copper falls if sugar be present.

Several objections have been made to this test, on the ground that mere uric acid is sufficient to reduce the copper, and thus introduce a serious source of fallacy. I confess that I have never met with any variety of urine which completely produced the above described phenomena with the test unless sugar existed. I believe the solubility of the precipitate first produced by liquor potassæ in an excess of the precipitant, and its depositing a dense red cupreous precipitate by heat, not continued after the liquid has acquired the boiling temperature, to be quite characteristic of sugar. This dense red deposit is very different from the light orange-coloured flocculent clouds which slowly subside when non-saccharine urine is employed.

Dr. Lionel Beale, in an excellent review on 'Sugar in the Urine, and its Tests,' in the 'British and Foreign Medico-Chirurgical Review,'* draws the following con-

* January, 1853.

clusions from many carefully performed experiments with reference to the practical application of the tartrate of potash and copper test, Barreswil, Fehling, and Trommer's tests.

1. That if the urine contain muriate of ammonia (even in very small quantities), lithate of ammonia (?), or other ammoniacal salts, the suboxide of copper will not be thrown down if only a small quantity of sugar be present.

2. That unless there be a considerable quantity of the above salts present, (in which case the blue colour will remain), the mixture will change to a brownish colour on boiling, but no precipitate of suboxide of copper will occur. Where only a small amount of sugar is present, we have been unable to obtain a precipitate, under these circumstances, by the addition of potash to the solution, and prolonged boiling. By previous observation* it appears that a specimen of urine exhibiting this reaction may contain a large quantity of sugar, as ascertained by the yeast test.

3. That in many cases in which the precipitation of the suboxide is prevented by the presence of ammoniacal salts, the addition of potash to the solution and subsequent boiling, will cause a precipitate with the evolution

* This refers to the following experiment. Upon mixing a small quantity of grape sugar with a specimen of healthy urine, and boiling the mixture with the tartrate test, no precipitate except what was owing to the presence of phosphates, was produced. About half an ounce of the same mixture of urine and grape sugar was placed in a test-tube and mixed with six drops of yeast and inverted over mercury. The whole was then placed in a temperature varying from 70° to 100° for about twelve hours, at the end of which time the tube was found quite filled with gas, and all the liquid was expelled into the vessel into which it had been placed. The specimen of urine with which the above experiment was tried, after cooling in a still place, gave an abundant precipitate of lithates.

of ammoniacal fumes. Hence care should always be taken that there a considerable excess of free alkali be present.

4. When only small quantities of sugar are present, and the precipitate of suboxide of copper is not decided, the fermentation test should be resorted to.

B. *Capezzuoli's test.*[110]—Add a few grains of blue hydrated oxide of copper to urine contained in a conical glass vessel, and render the whole alkaline by the addition of liquor potassæ. If sugar be present, the fluid assumes a reddish colour, and in a few hours the edge of the deposit of oxide acquires a yellow colour, which gradually extends through the mass, from the reduction of the oxide to a metallic state (suboxide?)

C. *Moore's test.*[113]—This very easily applied and excellent test was proposed by Mr. Moore, of the Queen's Hospital, Birmingham, and depends for its action on the conversion of colourless diabetic (grape) sugar into brown melassic (or perhaps sacchulmic) acid under the influence of a caustic alkali. Place in a test-tube about two drachms of the suspected urine, and add nearly half its bulk of liquor potassæ. Heat the whole over a spirit-lamp, and allow active ebullition to continue for a minute or two; the previously pale urine will become of an orange brown, or even bistre tint, according to the proportion of sugar present. The subsequent addition of an acid generally causes the evolution of an odour of boiling molasses. This test appears to be remarkably free from sources of fallacy, as boiling with liquor potassæ rather tends to bleach non-saccharine urine than to deepen its colour.* Dr. Rees has drawn attention to an important

* I have observed that many specimens of urine containing oxalate of lime, but void of sugar, assume a darker shade, as of sherry, on being boiled with liquor potassæ, and exhale a peculiar burnt odour.

error which may arise in the indications of this test from the solution of potass employed containing lead. When this is the case, the sulphur in the urinary excretion (99) produces a dark colour with the lead, and might lead to a suspicion of the presence of sugar when none exists. Hence it is important to preserve the test-solution in bottles of green glass free from lead.

D. *Maumene's test.*—Another test has been recently proposed which promises to be an important one. It is founded on the reducing power of sugar on salts of tin. To apply this, pieces of white merino, or any other woollen tissue, are soaked in a solution of bichloride of tin, and carefully dried. On wetting a piece of this test-cloth with urine, and holding it over a spirit-lamp or before a fire, so as to become hot, a deep brown or black spot will appear if sugar be present. M. Maumene states that ten drops of diabetic urine in half a pint of water will afford a mixture in which the mere traces of sugar present may be thus detected.

E. *Pettenkofer's test.*—This is founded on the production of a violet colour when sulphuric acid and bile are mixed with a saccharine fluid. I believe it to be so far inferior both in facility of application and accuracy of its indication to the last-mentioned test that it is unnecessary to give any further account of it than has already been done when pointing out the diagnostic indications of bile (320).

F. *Chromate of Potash test.*—This test has been proposed by Mr. Horsley, of Cheltenham. It consists of equal parts of a solution of the neutral chromate of potash and liquor potassæ. Mr. Horsley's description is as follows: If a freely alkaline solution of chromate of potash be mixed with urine supposed to contain sugar and boiled, the sugar will assume a deep sap-green colour, arising

from the decomposition of the chromic acid, the oxide of chromium being held in solution by the potash. Such is the sensitiveness of this test that five or six drops only of saccharine urine, diffused through water, is sufficient to show the effect, which is infinitely more striking than even Moore's potash or Trommer's copper tests.

When the quantity of sugar is very small, a piece of white paper should be placed at the back of the test-tube to render the colour more distinct.

The following experiments are easy, and illustrate the operation and value of the test:

1*st experiment.*—Take a small test-tube, and, having put into it ten or twelve drops of simple syrup (cane sugar) dilute with water, and add a few drops of the test. On the application of heat, no change will be produced.

2*d experiment.*—Take another test-tube, and having put into it the same quantity of simple syrup diluted with water, add two or three drops of dilute sulphuric acid, and boil for a few minutes. This will convert the cane into grape sugar. If we now add a few drops of the test, and apply heat, the liquid assumes an intense green colour.

G. *Fermentation test.*—Mix ordinary yeast, or dried German yeast, with water. Fill a test-tube with the diabetic urine, and add a little of the solution on the tube with the thumb, and, having inverted it, place it in a saucer containing the urine. Be careful to exclude the entrance of air. The temperature should not be below 70° Fahrenheit. If sugar be present, minute air-bubbles will rise and occupy the upper part of the tube. According to Dr. Christison one cubic inch of carbonic acid indicates one grain of sugar.

H. *Luton's test.**—This test is said to be easily

* 'Gaz. Méd. de Paris,' Jan. 27th, 1855. Ranking's 'Abstract,' vol. xxi, p. 87.

prepared and unalterable. Its action is immediate, no preliminary preparation of the urine is requisite, and it has often succeeded after the failure of other tests. The presence of uric acid, urea, or albumen has no influence on the result. Add sulphuric acid in excess to a cold saturated solution of bichromate of potash, so that after the liberation of all the chromic acid, free sulphuric acid may be present. It is, therefore, composed of water, chromic acid, bisulphate of potash, and an excess of sulphuric acid, and is of a beautiful red colour. Add the test to the diabetic urine till you get a red colour; apply the spirit-lamp, and a brisk effervescence ensuing, the colour changes from red to emerald green. The chromic acid is an energetic oxidizing agent, especially when another acid is present. It yields oxygen to the sugar, and carbonic acid, water, and sesquioxide of chrome result, the last of which, uniting with the acid, forms a persulphate of the sesquioxide.

I. *Polarized light.*—The apparatus for applying this test has been already described (52).

PHYSIOLOGICAL AND PATHOLOGICAL ORIGIN OF SUGAR.

Since the last edition of this work passed through the press, great light has been thrown upon the formation and destruction of sugar in the animal economy, more especially by the experiments and observations of Bernard, in Paris, repeated and extended in this country by Dr. Pavy.

The experiments of Bernard have established the fact that sugar is a natural constituent of the human body. It may be introduced as such into the stomach with the food, or it may be formed from the starch by the action of the pancreatic juice, or lastly it may originate in the

liver itself. Of these modes of origin it is only requisite to notice the last. Dr. Pavy, in the first of his two very interesting papers in the 'Guy's Hospital Reports,'* on the physiological relations of sugar in the animal economy, details the following experiment: A strong and healthy dog, which had been fed for three days on a strictly animal diet, was killed by pithing the medulla oblongata by means of a trocar inserted through the space between the occiput and atlas. The abdomen was opened, and a ligature placed on the portal trunk, and another on the abdominal vena cava, just above the entrance of the renal veins. The thorax was then opened, and another ligature placed on the inferior vena cava, immediately above the entrance of the hepatic veins; and portions of blood were separately collected from each of the above points, and submitted to chemical examination. The blood removed from the portal vein, which was supplied by the veins of the alimentary canal and other abdominal viscera, did not yield the slightest indication of saccharine impregnation; the blood from the abdominal vena cava below the hepatic veins also gave no trace of saccharine reaction, whilst that collected from the vena cava above the entrance of the hepatic veins, and likewise that squeezed from the hepatic veins themselves strongly reacted both with the fermentation and copper tests. From this experiment it is manifest that the blood must have become impregnated with sugar during its transit through the liver, but to complete the experiment Dr. Pavy analysed the tissue of the several organs and found that the tissue of the liver at once afforded evidence of the presence of sugar.

The liver, however, not only itself produces the kind of sugar which is called animal glucose, but also transforms into that substance the sugar which the portal vein

* Second Series, vol. viii, p. 319; and Third Series, vol. i, p. 19.

supplies from the results of digestion. In order to show this clearly, it is necessary to proceed a step further, and follow the blood impregnated with saccharine matter to the right side of the heart, and thence through the lungs to the left. The blood in the right ventricle gives abundant evidence of the presence of sugar, whilst that in the left ventricle contains comparatively but a mere trace. Hence it appears that the sugar is principally destroyed within the lungs. But if blood impregnated with cane sugar be transmitted through the lungs no such change takes place, and the blood in the left and right ventricles evince a similar reaction. Hence it may be safely concluded that the sugar in the portal vein is, during its passage through the liver, converted into some allied substance, which is known as animal glucose, and thus fitted for the change to be effected in its composition in the lungs, viz., conversion into lactic acid. But though the lungs are the *principal* seat of the destruction of the sugar, yet Dr. Pavy proved that the process of destruction was continued through the systemic capillaries, and that the sugar was never entirely absent, except in blood taken from the capillaries of the chylopoictic viscera, and that only when no sugar had been introduced into the alimentary canal with the food, and the animal was not at the period of full intestinal digestion."

Having now considered the seat of the destruction of the sugar, and the change which it undergoes in order to its conversion, we may review the circumstances upon which the conversion seems to depend. Experiments, varied so as to exclude sources of error, have determined that blood impregnated with animal glucose taken from one animal and passed through the lungs of another will give scarcely any saccharine reaction, provided it be not first deprived of its fibrin; but if the same experiment be

performed with defibrinated blood, no loss of sugar is observed. This change is not produced in pure blood alone, but is also observable in blood in a state of decomposition, especially if exposed to a current of oxygen. Hence it appears that a condition of molecular change is necessary to the production of saccharine metamorphosis, in illustration of which Dr. Pavy remarks that if "glucose or grape sugar be placed in contact with caseine in a state of decomposition (which implies molecular change) it is resolved by a process of fermentation into lactic acid." In the living system an identical transformation is induced by the molecular changes either of the assimilation or destruction of tissue. An alkaline condition of blood is also favorable to the process of metamorphosis. Dr. Pavy injected the dilute phosphoric acid into the jugular vein of a dog, and on examining the blood drawn from the carotid artery, he found it largely impregnated with sugar. In another case he injected one hundred grains of the crystallized carbonate of soda, dissolved in eleven drachms of water, into the jugular vein, and then examined the blood taken from the carotid artery; but in this latter case the blood evinced the same reaction as ordinary arterial blood. These experiments have also determined that an injury to the pneumogastric nerve in its point of origin in the fourth ventricle may produce an attack of diabetes, because such injury either increases the quantity of glucose secreted by the liver, or deprives the liver of its power of converting cane sugar into animal glucose, or so impairs the functions of the lung as to check or retard those molecular changes, which are requisite for converting animal glucose into lactic acid.*

* The weak point in the argument is that this acid can scarcely be detected in the blood; but when we remember the close alliance in composition

Dr Bence Jones has suggested that as gout arises from deficient oxidation of uric acid—nitrogenous compounds—so possibly diabetes may arise from deficient oxidation of the non-nitrogenous compounds.

These conditions, therefore, appear to be requisite for the process of saccharine metamorphosis, viz., 1. Presence of molecular change. 2. Exposure to atmospheric air or oxygen. 3. Alkaline condition of blood.

Therapeutical indications.—The true therapeutical indications in diabetes can never be satisfactorily determined, unless first the cause and source of the mischief (fons et origo mali) be understood. We have already seen that sugar is a natural constituent of the human body; that if it be not introduced from without, the system has been supplied with means of manufacturing it within; and also that certain conditions are necessary for the due completion of its metamorphosis, and that these conditions are fully provided in the healthy body. Diabetes may originate from these conditions being interfered with in one of the following modes:

1. A greater amount of sugar may reach the liver than that organ is capable of converting into animal glucose; in which case the excess passes unaltered through the lungs into the systemic circulation, and being useless for the purposes of combustion or nutrition, is excreted by the kidneys. This is probably the history of those very interesting cases of intermitting diabetes of old people, upon which Dr. B. Jones has ably written. The remedy is dietetic, with stomachic alteratives, such as rhubarb,

between sugar ($C_{12}H_{12}O_{12}$), and lactic acid (C_6, H_6, O_6), also that on the completion of saccharine destruction in decomposing blood, there is a decided acid reaction, also that lactic acid is separated from the capillaries in the stomach and muscular tissue, we are, I think, justified in predicating its existence in arterial blood.

soda, and calumba, and small doses as pilula hydrargyri; but in most cases of this kind regulation of the diet is all that is necessary.

2. The liver may, through or by reason of irritation of the brain or pneumogastric nerve, secrete a larger quantity of sugar than can be metamorphosed in the lungs.

3. The lungs, through a similar injury or irritation, may be rendered unfit to fulfil their part of the process. In such cases, as well as those referred to in the preceding paragraph, we must allay the cerebral irritation, regulate the diet, and prescribe alteratives and purgatives.

4. The function of the liver may be so impaired as to be incapable of converting the cane sugar supplied to it through the portal vein into animal glucose. Consequently, the conversion into lactic acid is impeded or prevented, and the sugar is discharged as a foreign body through the kidneys.

In the first class of cases I have referred to regulation of the diet as in most instances of itself sufficient to cure the disease. But attention to this point is no less necessary in the other classes. Before giving the chart which I generally prescribe, I will detail the composition of the bread which forms a prominent part of it.

Place one pound of bran in an oven, and bake for a quarter of an hour; then, while still warm and crisp, transfer it to a pepper or fine coffee-mill, and rapidly grind it. Put the ground bran into a basin and mix with it half a pound of fresh butter, the yolks of six eggs, one drachm of bicarbonate of soda, and milk enough to make into a paste, then divide into thin cakes, and bake rapidly in a *quick* oven.*

* Mr. Camplin has published, in the 'Medical Times and Gazette,' May 2d, 1857, the following formula for bran loaf which contains no starch. Take a sufficient quantity, (say two or three quarts), of wheat bran,

These cakes, with fresh butter or cheese, are much relished by the patient for lunch.

The following is, perhaps, the best diet-table for diabetics:

Breakfast.—Rasher of bacon, or chop, or eggs, with bran bread or slices of white bread, cut rather less than a quarter of an inch thick, and toasted so as to be brown throughout, no white unchanged bread being left in the middle. Coffee, tea, or cocoa* with milk.

Dinner at 1·30 p.m.—Fresh meat, poultry, or fish of any kind. All vegetables freely, excepting potatoes, carrots, parsnips, celery, beetroot, and artichokes.

boil it in two successive waters for ten minutes, each time straining it through a sieve; then wash it well with cold water, on the sieve, till the water runs off perfectly clear; squeeze the bran in a cloth as dry as you can, then spread it thinly on a dish, and place it in a slow oven; if put in at night let it remain until the morning, when, if perfectly dry and crisp, it will be fit for grinding. The bran thus prepared must be ground in a fine mill,† and sifted through a nice sieve of sufficient fineness to require the use of a brush to pass it through; that which does not pass through at first must be ground and sifted again, until the whole is soft and fine.

Take of this bran 3 ounces, troy, 3 fresh eggs, 1½ ounce of butter, rather less than half a pint of milk; mix the eggs with part of the milk, and warm the butter with the other portion; then stir the whole well together, adding a little nutmeg and ginger, or any other agreeable spice. Immediately before putting into the oven, stir in first 35 grains of sesquicarbonate of soda, and then 3 drachms of dilute hydrochloric acid. The loaf thus prepared should be baked in a basin, previously well buttered, for about an hour or rather more. Biscuits may be prepared as above, omitting the soda and the hydrochloric acid, and part of the milk, and making of proper consistence for moulding into shape.

If properly baked, the loaves and biscuits may be preserved several days, but should always be kept in a dry place, and not be prepared in too large quantities at a time.

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* The cocoa must be ground at home.

† Made by Mr. White, of Holborn.

"Omelettes aux fines herbes" for puddings or custards made without flour or sugar, bran bread and cheese with lettuce or water-cresses.

Tea.—Like breakfast, omitting the meat.

Supper at 9 o'clock p.m.—Bran bread and butter, a basin of rice milk without sugar, or sandwich of meat and toasted bread.

Plain Bordeaux claret is the best wine. It contains no sugar, and relieves thirst. Alum whey is recommended, in Dr. Buchan's Medicine, as a drink, and I have found it useful in allaying thirst. Our treatment by medicines is either rational or empirical—the former embraces all those remedies, which have a tendency to favour the conversion of cane sugar into animal glucose, as yeast, pepsine, rennet, liquor potassæ, sesquicarbonate of ammonia, &c., or to facilitate the metamorphosis of the animal glucose into lactic acid, as strychnia (?);—the latter comprises a long list of remedies which have been administered with the view both of stimulating and arresting the urinary secretion, or of preventing the formation of glucose. The treatment by rennet, aided by strict attention to diet, has, in many instances, proved successful; the liquor potassæ, in half drachm doses, taken shortly after a meal, in favorable cases, has been very beneficial, especially if in conjunction with treatment by rennet, yeast, oils, &c. Milk just turned sour is recommended by Dr. Headland, as it contains caseine in the process of decomposition, and we have already observed that the presence of decomposing caseine favours the metamorphosis of animal glucose into lactic acid. With all plans of treatment it is necessary, as far as possible, to restore the healthy action of the skin, liver, and bowels.

B. *Fungoid (confervoid) growths apparently distinct from Torulæ (Penicilium?)*

352. Heller described some vesicular growths evidently allied to the genera Torula or Penicilium in the urine of a patient labouring under typhus fever. He gave figures of them in a paper published in his 'Archiv fur Physiologysche Chimie' for 1846. During the autumn of 1849, similar growths were discovered by my friend Dr. Basham in the urine of dyspeptic patients. These observations were made quite independently of Heller's paper, of the existence of which Dr. Basham was at that time not aware. He met with these bodies in the urine of a patient who was passing stellar crystals of uric acid. They consisted of oval cells arranged by their long diameters in a bead-like form, with minute granules or cellules developing themselves from the surface and points of juncture of the parent cells (fig. 76).

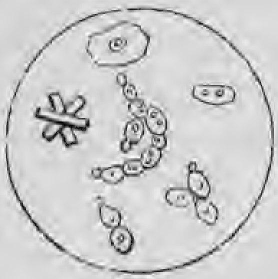

Fig. 76.

Fig. 77.

353. Another, and apparently very different fungoid vegetation was discovered nearly at the same time by Dr. Basham, in the urine of a patient who was suffering

from symptoms suspected to be dependent upon oxaluria. It had been passed twenty-four hours, and mixed with the crystals of oxalate of lime were numerous annular cells, some were furnished with minute nuclei. Most of them were more or less elliptical, some split in half like a horse-shoe. They are shown in fig. 77, mixed with crystals of oxalate of lime. Their apparent annular structure is probably owing to their being thicker at the margin than in the centre. And in this they bear no small resemblance to dried specimens of *uredo* and *puccinia*, the former so common on wheat, the latter on rose-buds. The most interesting fact connected with these observations consists in their having been made at the very time when great attention was directed to the fungoid theory of cholera, which disease was then prevailing with fearful virulence. The annular bodies discovered by Dr. Basham, in the urine of a dyspeptic patient, being apparently identical with those described by Dr. Brittan as existing in the serous dejections of cholera patients. On submitting some specimens of these intestinal fluids to careful microscopic observation, Dr. Basham discovered the very important fact that the annular bodies were not to be detected in the very recently excreted fluids; four hours subsequently a few were found, and in fourteen hours they were abundant. It is hence impossible to regard these organisms as in any way constituting the exciting cause of the terrible disease of which they had been stated to be the constant accompaniment.

Dr. Hassall has made several very interesting observations on the subject of the growth of torulæ in the urine, and confirms the opinion that the fungus of saccharine urine is really the yeast-plant, and differs materially from the fungus developed in non-saccharine urine, which is identical with the *penicilium glaucum*; the former has been

already noticed. The latter was traced through its three stages of sporule, thallus, and fructification, well represented by figs. 78 and 79, taken from Dr. Lionel Beale's works

Fig. 78.

Fig. 79.

on the microscope. The conditions necessary for its growth were found to be animal matter, especially, but not exclusively, albumen, acidity, and the presence of oxygen (exposure to atmospheric air). The *penicilium glaucum*, though distinct from the sugar-fungus, yet is not unfrequently found associated with it, as the conditions necessary for its growth are generally present in saccharine urine.*

C. VIBRIONES.

354. Minute animalcules, belonging to the genus Vibrio (V. Lineola ?[111]), are occasionally developed in urine, so soon after passing as to lead to the idea that their germs must have existed in the urine whilst in the bladder. All the urine in which I have found these

* 'Medical Times and Gazette,' Dec. 4th, 1852; and Ranking's 'Abstract,' vol. xvii, p. 88.

minute creatures has been pale, neutral, of low specific gravity, and rapidly underwent the putrefactive fermentation.

When a drop of such urine is examined under the microscope between plates of glass with an object-glass of one eighth inch focus, it will be found full of minute linear bodies hardly so long as the diameter of a blood-corpuscle (about $\frac{1}{3000}$ inch) moving with great animation. The motion is of an oscillating character, and strong enough to excite tolerably rapid currents in the fluid. Even under a very high magnifying power, no satisfactory evidence of organization can be detected in these minute beings.

355. I have only met with these animalcules in the urine of persons in an excessively low and depressed state. In cases of syphilitic cachexia, where the prostration of the strength is extreme, as well as in mesenteric diseases, I have repeatedly found them abundantly developed, with remarkable rapidity. They appeared in great abundance in the urine of a patient under my care at Guy's Hospital two years ago. The subject of this case was a most miserable looking young man, who entered the hospital half-starved, and labouring under polydypsia, passing a very large quantity of urine of low specific gravity. He died of rapid phthisis in a few weeks, the urine became full of vibriones in active motion a few hours after being passed.

MILK.

356. No satisfactory case is recorded by any observer of credit, in which milk has been discovered in the urine; although there are few who have devoted themselves to investigations connected with the pathology of the urine,

but have met with urine rendered opaque by the fraudulent admixture of milk,—a piece of deception occasionally practised by persons who labour under the unintelligible delusion of wishing to appear the subjects of some marvellous disease. All the cases of milk-like urine, where no fraud has existed, are instances of phosphatic (258), purulent (328), or fatty (370) urine. Although milk itself does not occur in urine, yet there can be little doubt that some of its elements may be met with in it, by a kind of vicarious action of the kidneys, in the same manner that bile is. It must be remembered that milk consists of globules of fatty or oily matter floating in a fluid or serum in which a peculiar protein-compound, *casein*, is dissolved. This substance is distinguished from other protein-principles by the action of acetic acid, which immediately coagulates it, producing the well-known curd, the basis of cheese. The most interesting subject connected with the supposed presence of this substance in the urine, is its apparent connection with utero-gestation; and its temporary occurrence when an obstruction occurs to the ready escape of milk from the breast.

357. An account of the supposed discovery of a peculiar mucilaginous principle in the urine of pregnant women appeared a few years ago in several of the British and foreign medical journals,[99] and attracted much notice as a diagnostic sign of pregnancy. This new constituent of the renal secretion, to which the name of *Kiestein* was applied, was stated to exist in the urine of the human female during utero-gestation, and to become visible when the secretion was allowed to repose in a cylindrical vessel, in the form of a cotton-like cloud, which in a lapse of time, varying from the second to the sixth day of exposure, became resolved into a number of minute opaque bodies, which rose to the surface, forming a fat-like scum

and remaining permanent for three or four days. The urine then became turbid, and minute flocculi detached themselves from the crust, and sank to the bottom of the vessel: this action continued until the whole pellicle disappeared. This crust of kiestein was stated to be distinguishable from analogous pellicles which occasionally form on the surface of urine, from its never becoming mouldy, or remaining on the surface beyond three or four days from the time of its complete formation.

358. This subject appeared of sufficient importance to justify a minute investigation, the results of which were published in the 'Guy's Hospital Reports' for 1840. As nothing has appeared since to induce me to modify the opinions I then made public, I now republish the most important part of these remarks.

The first specimen of urine submitted to examination was some voided by C— S—, aged 28, a married woman, in the sixth month of pregnancy, admitted under my care at the Finsbury Dispensary, on October 17th, 1839, for a slight attack of bronchitis. The urine was passed immediately on rising from her bed; it was tolerably copious, pale, acid, and rather opaque, of sp. gr. 1·020. About half a pint of it was placed in a glass cylinder, covered with paper. After two days' repose, it became very much troubled; numerous globules, presenting a fatty or greasy aspect, appeared on its surface; in two days more the urine became completely covered with a pellicle, very closely resembling that which forms on the surface of mutton-broth in the act of cooling; on the sixth day of exposure, this crust broke up, and fell to the bottom of the vessel. On the 26th of October, this patient, then convalescing from her bronchial affection, again sent me a specimen of the urine, voided as before, immediately after awaking from sleep; and the very same results were

obtained; the pellicle of fat-like matter being, however, much thicker. On November 30th, the urine was again exposed, with precisely identical results. Although in this woman the phenomena presented by the urine were tolerably constant, yet it became an important matter to determine whether such appearances were not to be met with in the urine of women who were not pregnant, and whether they were constant in every case of utero-gestation. To determine the latter question was, within certain limits, somewhat easier than the former; for this purpose, every pregnant woman who came under my care at the Finsbury Dispensary, or among my out-patients at Guy's Hospital, was desired to furnish specimens of urine, passed after awaking from sleep; this request was not in every instance complied with; but during the months of November and December, specimens from about thirty women, in the third to the last month of pregnancy, were obtained; and in every case, with but three exceptions (to which I shall hereafter allude), copious fat-like pellicles were observed, after two or three days' exposure. The three women whose cases thus appeared to be exceptions to the general rule, were all affected with inflammatory fever accompanying severe catarrh. Their urine was turbid with urates. On the disappearance of the latter by the convalescence of the patients, the phenomena characteristic of pregnancy appeared.

359. Whilst collecting these specimens of the urine of pregnant women, I directed several young women, who presented themselves to be treated for amenorrhœa, to bring specimens of their urine; which were exposed simultaneously with those furnished by the pregnant women;—and in two instances only was any evidence of the presence of the peculiar matter manifested. In one, a servant girl of 18 years of age, I strongly suspected

pregnancy, from the appearance of the areola around the nipple; but she was so much annoyed at my questioning her on this point, that she ceased to attend. The second case was more satisfactory: it was that of a stout, tall, unmarried woman, a servant, aged 33, who came under my care November 7th, 1839, suffering from cough, apparently depending upon deranged digestive functions and relaxed uvula: she had not menstruated since the preceding May, and attributed the disappearance of the catamenia to exposure to cold. She had morning sickness, and the veins of her lower extremities were varicose. On examining the abdomen, no evident enlargement of the uterus could be observed, in consequence of the parietes being loaded with fat; and on looking at the breasts, the nipples were found surrounded by a large purplish-brown areola. On being charged with pregnancy, she obstinately denied it; but admitted having been the mother of an illegitimate child eleven years previously. She declared that she had preserved absolute chastity since that period, and wept bitterly at my (as she termed them) unjust suspicions. I procured a specimen of her urine, and exposed it in a lightly covered glass cylinder: in two days, a dense pellicle of fat-like matter formed on its surface: this increased in thickness during three days, and then evolved so powerful an odour of putrefying cheese, that I was obliged to throw it away. Five months later this woman was delivered of a male child.

The odour of putrescent cheese remarked in this case, is by no means unfrequent in those specimens of urine in which the pellicle is very thick.

360. None of the specimens of urine voided by pregnant women that I examined, were coagulable by heat, nitric acid, or, with but two or three exceptions, by acetic acid, and therefore could not contain any con-

siderable portion of albuminous or caseous matter. The addition of ammonia almost invariably produced a dense deposit of earthy phosphates; and, with the exception of this proof of the existence of an excess of earthy phosphates in the secretion, no appreciable portion of any abnormal ingredients could be detected.

Some of the fat-like pellicle was removed from the surface of urine on which it had formed, by plunging a plate of glass perpendicularly into the fluid, and withdrawing it adroitly, in a nearly horizontal position: an equable layer of the substance was thus procured; and, when carefully covered with another plate of glass, it could be very conveniently submitted to examination.

The pellicle thus procured, appeared glistening with a lustre like that of spermaceti; when placed under a microscope, and examined with an object-glass of a half-inch focal length, myrians of triangular prisms of triple phosphate (264) were seen imbedded in a mass of granular matter, mixed with which might here and there be seen patches of fat-globules. The prisms of triple phosphate were so beautifully distinct, and their angles so sharply defined, that the whole became a most interesting microscopic object: some of the crystals were placed on end, and thus appeared like triangular plates.

When the urine is kept so long that the pellicle begins to break up, it falls, in the form of a deposit, to the bottom of the vessel. If the supernatant fluid be decanted, and the deposit collected on a slip of glass, it is found to present the same appearance as the pellicle; excepting that the crystals are much more numerous, and all the animal matter present is entirely composed of amorphous granules, all trace of anything like a regular structure being lost.

361. A slip of glass, on which a portion of the pellicle

had been collected, was placed under the microscope, and covered with a few drops of acetic acid: the whole became opaque, the crystals were rapidly dissolved, and a white pultaceous mass resulted. On washing it with a few drops of water, and carefully drying the residue, the animal matter was left upon the glass in a white opaque layer, in which no trace of crystalline matter was perceptible, upon very minute microscopic investigation.

Another portion of the pellicle, also collected on a glass plate, was placed under the microscope, and a few drops of strong liquid ammonia were added: the crystals underwent no change, but became much more distinct from the opaque matter, in which they we imbedded, undergoing solution. In the course of half an hour, the glass was carefully washed with a little water, and again examined, when every trace of animal matter was found to have disappeared, and the crystals of the triple phosphate were alone left.

362. From these investigations, it is evident that the greasy aspect of the pellicle of the so-called *Kiestein* arises less from the presence of fat, than from the numerous crystals of triple phosphate, which, from their brilliancy, produce this glistening appearance. Some fatty matter is, however, present, and Lehmann,[100] in repeating these observations, discovered that on digesting the pellicle in ether and allowing the etherial solution to evaporate, a fat was obtained which closely resembled butter, and when saponified with potass, yielded butyric acid (100) on the addition of sulphuric acid. Dr. Rees[137] has also detected genuine fat-globules, precisely like those found in milk. With regard to the nature of the animal matter soluble in ammonia, mixed with these crystals, it is difficult, in the present state of physiological chemistry, to give a positive opinion. It is not

mere albumen or casein, although much more closely allied to the latter than to any other product of organization I am acquainted with, especially when we connect with its chemical characters the powerful cheese-like odour so frequently evolved, during its development in the urine, in the form of a pellicle. To this view may be objected the circumstance that the urine yielding it does not coagulate on the addition of acetic acid; this, however, is by no means an important objection, as milk, when very much diluted with a saline solution, or even water, is not perceptibly troubled by acids. The pellicle may be regarded as possibly constituted of an imperfect caseous matter, mixed with traces of butter and crystals of the ammoniacal phosphate of magnesia. It has been proposed indeed to dignify the animal matter present in this mixture with the name of *gravidine*, but we are not justified in considering it as constituting a new organic principle.

There are few products formed during repose in urine which can be readily confounded with this caseous pellicle, if it be borne in mind that the secretion remains faintly acid up to the moment of the crust breaking up; which phenomenon seems to depend upon the development of ammonia in the urine, as at that time it acquires distinct alkaline properties. The crust of earthy phosphate, which forms on the surface of all urine by long repose, cannot be mistaken for the pellicle under consideration; as that which destroys the latter, viz., putrefaction, causes the production of the former.

363. If it be granted that we possess sufficient evidence of the presence of certain ingredients of the milk, as an imperfect caseous matter, and abundance of earthy phosphates, in the urine of pregnant women, it might be suggested as a probable explanation, opposed to no phy-

siological views that I am acquainted with, that during utero-gestation, certain ingredients of the milk are eliminated from the blood by the mammary glands, and, as is very well known, often accumulate in the breasts, in sufficient abundance, to escape from the nipple on pressing it between the fingers. This imperfectly formed secretion, not having a ready exit by the mammæ, is taken up into the circulating mass, is separated by the kidneys, and eventually escapes with the urine. This view is certainly sanctioned by the statements of a high authority, Professor Burdach[101] of Konigsberg, and although not quite consonant with the opinion of M. Rayer,[102] yet it is in accordance with what we find occurring, under certain circumstances, in the bile, in the cases of obstruction of the biliary ducts; and more rarely in the urine, when, from the presence of calculi or other causes, the ureters are completely obstructed.

364. At a late meeting of the Academy of Science of Paris, MM. Grullot and Leblance announced their discovery of casein in the blood during lactation. They examined the serum of blood obtained from two persons who were nursing infants. After coagulating the albumen by heat, and separating it by filtration, they found that the addition of acetic acid produced an abundant precipitate of casein. The quantity of this substance present seemed to bear a direct ratio to the proportion of albumen in the blood. These observations render the excretion of casein by the kidneys, in accordance with the law of Wohler, at least a probable circumstance (383).

365. Although it is extremely probable that similar pellicles, which I have assumed to be characteristic of the presence of certain elements of milk in the urine, may be met with in the renal secretion of nurses whilst suckling, yet I have never met with an instance of this kind:

indeed, the following interesting case appears rather opposed to this view:

Oct. 26, 1839. I was consulted by Mrs. T——, then in the third month of utero-gestation, on the case of her child, a boy sixteen months old, whom, notwithstanding her pregnancy, she was then suckling. This little patient had a severe attack of pneumonia following measles, from which he was recovering, when, a few days before I was called in, from imprudent exposure to cold, he contracted bronchitis; and when I saw him he was evidently dying: he had, however, sufficient strength to take the breast. As it was evident that the child would in all probability expire in a few hours, I was anxious to ascertain whether the urine of the mother contained any of the supposed caseous matter; and if not, how long after the death of the boy it would appear. Some of her urine was collected; and, after six days' repose, it underwent no particular change. Putrefactive decomposition then commenced, and it was thrown away. She continued to suckle her child until within a few hours of its death, which took place forty-eight hours after my first visit; and on the following day I procured another specimen of the mother's urine. This, after a two days' repose, had a thin caseous pellicle on its surface. In the course of a week, a third specimen was procured; and this in three days became covered with a complete creamy layer, evolving a strong cheese-like odour.

This case certainly appears to justify the idea that, whilst suckling, the milk being got rid of almost as quickly as it is secreted, none of its elements find their way into the urine; but as soon as the milk ceases to be removed in this way, indications of it are to be met with in the urine, providing pregnancy exists. The following case appears to support the position I have assumed:

E— C—, aged 24, suckling her first child, five months old, admitted under my care, at the Finsbury Dispensary, in December, 1839, complaining of symptoms generally referable to asthenia lactantium. She was a tall, thin, delicate-looking woman, and had lost a mother, and some collateral relations from consumption. She had little or no cough; on examining her chest, I detected tubercular deposit at the apices of both lungs, with evidence of commencing softening on the left side. Her urine was pale, and free from any appearance of caseous pellicle. I desired her to wean her infant; but this she did not do until January 27th, 1840. When she sent her child away, her breasts became painful and hard. She was compelled to have them drawn; and in a week they became flaccid, and the secretion of milk stopped. On January 30th, the breasts being still turgid, and three days after the cessation of suckling, some of her urine was collected, and exposed in a glass cylinder. In the course of four days a cream-like pellicle, evolving a cheese-like odour, was observed. On collecting some of it on a slip of glass, and examining it under the microscope, it was found to resemble the usual pellicle which forms, by repose, on the urine of pregnant women in every respect, except in the extreme paucity of the crystals of triple phosphate; the entire portion of the pellicle examined being nearly entirely composed of the animal matter, insoluble in acetic acid. A few days afterwards the urine was again examined, but with negative results; no evidence of caseous matter, as indicated by the formation of a pellicle, could be detected.

366. It is not known how soon after conception the urine assumes the properties characteristic of pregnancy. In one case, that of a woman who considered herself to be at the end of the second month of her pregnancy, the

urine yielded a well-marked pellicle; but I do not place much confidence in this observation, as the woman might very likely err in calculating how far she was advanced in utero-gestation. Kleybolte,[138] who, in common with many others, considers the presence of kiestein as quite indicative of pregnancy, has asserted that he detected it in the urine on the fifth day after conception.

As a test for the existence of pregnancy, the formation of the caseous pellicle, especially if accompanied by a cheese-like odour, will be an extremely valuable *corroborative* indication; but it would be unsafe to found on it alone any positive opinion, because, as a sufficient number of observations have not yet been made on this subject, we have no right to assume, however probable it may be, that a caseous pellicle can appear *only* when pregnancy exists. This opinion I feel still inclined to maintain, notwithstanding the very opposite opinion advanced by different observers, some of whom have declared the kiestein to be pathognomonic of pregnancy, and others have expressed a conviction of its utter worthlessness.

Whilst the sheets of the third edition of the work were passing through the press, a very interesting case, in which the urinary diagnosis of pregnancy proved to be of great importance, occurred in the practice of my colleague, Dr. Gull. I prefer giving an account of it in his own words, on account of the many points of interest in this curious case:

My dear Dr. Bird,

At your request, I send you the particulars of the following case of *mole pregnancy*, which illustrates the importance of examining the urine as a means of diagnosis. The age of the patient and the other circumstances of the

case made it somewhat difficult to determine with certainty the state of the patient, but the presence of the caseous substance in the urine was so indicative, as you have pointed out, of that physiological state which occurs only in pregnancy, that I felt very confident in the opinion it led to, and the result of the case showed that its importance had not been overrated.

In the autumn of 1849, I was consulted by a lady in her 50th year, the mother of a large family, who informed me that the catamenia, which had been previously regular, had ceased for four months, and that for three months she supposed herself pregnant, when, after being much excited by the misconduct of a servant, her symptoms changed; the breasts became flaccid, the abdomen did not enlarge, and a slight vaginal discharge, of a reddish-brown colour and faint acid odour, had since troubled her. I found the papillæ about the nipple prominent, and there was a distinct fulness at the lower part of the abdomen, but no uterine sounds could be heard. Having set apart a few ounces of her urine for several days, a large amount of kiestein separated, and this, together with her history, led me to regard it as one of pregnancy with threatened abortion. For three successive weeks the urine contained kiestein, but after this no traces of it could be discovered. For the following two months, the case went on without any change, the discharge continuing; but all symptoms of pregnancy had disappeared, and the abdomen did not enlarge. Seven months having now elapsed from the beginning of the symptoms, it was thought prudent to expel the contents of the uterus, and for this purpose Dr. Lever, who was consulted, advised the use of the ethereal tincture of ergot, and within twenty-four hours a large mole was expelled, consisting of degenerated chorion, partly vesicular. No traces of a fœtus could be found.

From this time the uterine discharge ceased, and the patient was soon in her usual health.

I am yours faithfully,

William W. Gull.

Guy's Hospital;
Nov. 14th, 1850.

FATTY MATTER.

367. A very minute trace of fatty matter is not unfrequently present in urine, and in some rare instances it increases in quantity, so as to become an important element of the secretion. The majority of cases of this kind hitherto recorded have not been very satisfactory, in consequence of the general dearth of detail respecting both the chemical and microscopical characters of the supposed fatty fluid. In some cases oil has been said to have been seen floating on the surface of the urine in large drops, even to the extent of ounces;[103] but no instance of this kind has ever occurred to me, and I suspect that certainly, in most of such cases, a fraud has been practised by the patient. An oil-like pellicle, often observed on the surface of urine, from the formation of a pellicle of earthy phosphates, may have been mistaken for true fat. It has been lately shown, that during pregnancy a portion of butter-like fat may form part of the pellicle which forms on the urine by repose (362). All genuine specimens of fatty urine that have occurred to me have been opaque, like diluted milk, and in the majority of instances have spontaneously gelatinized, like so much blancmange, on cooling. To these the term of *chylous urine* has been applied by Dr. Prout.[104]

368. Great interest has become attached to the existence of fat in the urine, from the researches of Dr.

Eichholz, and of Dr. G. Johnson, who have stated that fatty matter not only exists in abundance in the urine in granular disease of the kidneys, but is even pathognomonic of that affection. According to Dr. Johnson, fat or oil-globules naturally exist in the epithelial cells of the tubular structure of the kidneys; and in the disease in question the fat increases so rapidly as to press upon the venous capillary plexuses on the exterior of the tubuli, so as to interfere with the return of blood from the organs. On the cells giving way or escaping from the tubuli, their fatty contents become mixed with the urine.

369. The quantity of fatty matter thus mingled with the urine is far too small to cause it to assume any appearance by which its presence can be detected by the naked eye. It is generally only to be detected by examining the deposit which subsides from such urine by repose, and the epithelial cells (fig. 80 *a*) filled with fat-globules and sometimes even casts of tubes containing them (fig. 80 *b*) may be observed. Dr. Johnson does not assume that this evidence of fatty degeneration is essentially present in every case of Bright's disease, but that it is pathognomonic of one of the most frequent forms of that most serious disease.*

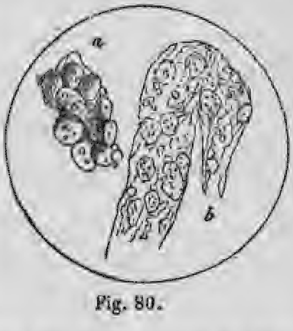

Fig. 80.

* This point has been more fully noticed in connection with the subject of renal casts, p. 345.

Chemical Characters of opaque Fatty Urine (chylous urine?)

370. On agitating the fresh urine with an equal bulk of ether in a tube, the fat is dissolved, and by repose a yellow ethereal solution of it will float on the top of the urine, which, by thus losing the fat, becomes nearly transparent. On decanting the solution, and allowing it to evaporate in a watch-glass, the fat is left in little yellow globules, like butter, and having a rancid odour. This fat readily melts by a gentle heat into a yellow oil, and slowly solidifies on cooling.

Albumen often exists in chylous urine in its spontaneously coagulable form (fibrin), so that on cooling it readily assumes the figure of the vessel. In this respect the urine often remarkably varies, sometimes losing its power of spontaneous coagulation for days together. Albumen is, however, even then present, and readily coagulates on the application of heat and nitric acid (317). In some cases which occurred to Dr. Prout, the albumen did not coagulate by heat, although it did by nitric acid; he hence considered it to be in an imperfect or hydrated state, like the albumen of the chyle. If a large proportion of fat exists, the fibrin, if present, is often prevented by its presence from coagulating; in this case, after agitation with ether, so as to dissolve out the fat, a delicate tremulous transparent coagulum of fibrin will form on the surface of the urine, and beneath the ethereal solution of fat.

371. *Microscopic characters.*—Cases have been reported in which globules of fat, like those existing in milk, were detected by the microscope. In all the specimens I have examined, the fat appeared to form a most intimate

mixture or emulsion with the albumen, so that under the microscope nothing could be detected except myriads of infinitely minute particles floating in the fluid, generally unmixed with the slightest appearance of a globule of oil. More rarely, however, the oily matter was readily to be observed in distinct globules, resembling those seen in milk.

372. *Pathological indications.*—These can scarcely be said to be accurately known. In the few instances I have witnessed of fatty urine, the patients have (with one exception, occurring some years ago in a lady, a native of China, remarkable for her emaciated condition, under the care of Dr. Protheroe Smith) shown a remarkable disposition to obesity. The continued presence of albumen co-existing with the fat, must, however, excite our alarm, for fear of the probable termination of the ailment in diseased kidney and resulting in dropsy, especially if the recent statements of Dr. G. Johnson (369) are corroborated by more extended observations. In these cases there can be no question, notwithstanding the occasionally repeated assertion that albuminous urine is not always connected with renal mischief, that our most serious apprehensions must be entertained for the welfare of our patient. The more extended our experience becomes, the more correct does the law laid down by Dr. Bright, of the almost necessary connection between persistently albuminous urine and diseased kidney, appear.

373. I was indebted for the opportunity of investigating a well-marked case of this affection to the kindness of the late Mr. Montague Gossett, in whose practice it occurred. This case was peculiarly interesting on account of several curious anomalies it presented, as well as from its affording an opportunity of correcting the account generally given of the microscopic characters of urine containing fat.

The first specimens of the urine from the patient to which I have referred were given to me on April 14th, 1844, with an inquiry as to their nature; one specimen was of specific gravity 1·018, somewhat paler than usual, and was perfectly transparent, with the exception of a slight mucous cloud. The other specimens, stated to have been passed some hours before the former, resembled milk in colour and general appearance, and was quite free from any urinous odour. It was faintly acid, of specific gravity 1·020; the addition of either nitric or hydrochloric acid produced a considerable curdling. By repose, a cream formed on the surface of the urine, forming a layer one-tenth the thickness of the whole volume of fluid. When a drop of this milky urine was placed under the microscope, no oily globules could be seen when examined with an excellent object-glass of one eighth of an inch focus, by Powell; the turbidity appears to have depended upon an immense number of particles, so minute that under a magnifying power of 800 diameters they resembled mere points.

I confess that I could not help suspecting that some addition had been made to the urine by the patient after its being passed; an idea that at first gained some support from the fact that when the bladder was emptied by means of the catheter, the urine removed was found to be quite transparent and healthy.

On April 22d, I saw Mrs. T— in bed. She was an extremely fat, flabby woman, about 35 years of age, the mother of several children. She expressed herself as quite well with regard to her general health, and only complained of the occasional milky state of the urine as possibly indicative of some threatening ailment. She stated to me that for several years she had been accustomed o pass milky urine, especially during part of her

pregnancies. On several occasions the urine, although not milky, had gelatinized on cooling so as to assume the form of the vessel like so much ordinary jelly. The appearance of the milky urine was exceedingly capricious, sometimes being constant for weeks together, and then disappearing for some time. She could trace no apparent connection between its appearance and any obvious exciting cause; it bore no evident relation to the quality, quantity, or hours of her meals, nor to the periods of menstruation. The only general rule she had observed regarding its appearance was that it most frequently appeared when she first voided urine on rising from bed, and hence she fancied it was produced by lying on her back all night. It had become most frequent in its appearance since she had begun to grow fat.

My visit was made about 2 p.m.; Mrs. T— had not risen, except to pass water, since the preceding evening. Three specimens of urine were shown me as having been passed since an early hour in the morning.

The first specimen was like ordinary urine; contained an abundance of pinkish urates, which disappeared by heat; it was acid, and not coagulable; contained no albumen.

The second specimen was as pale as water, subacid, and, on heating it, clouds formed in it from the coagulation of albumen.

The third specimen was of a healthy amber colour; it appeared natural, and was free from albumen.

The examination of these specimens certainly gave no satisfactory explanation of the nature of the milky urine she had previously passed, and she declared that this was the first occasion on which she had failed to pass that kind of urine for some weeks. I introduced a catheter into the bladder, and a pint of fluid escaped, possessing

the odour, colour, and general appearance of hot milk and water; in fact, having none of the physical characters of urine.

The specimen thus obtained was of specific gravity 1·010, slightly acid; by repose a cream-like layer formed on its surface, leaving the lower portion of the fluid nearly transparent. I may remark that Mrs. T— had not partaken of any food since breakfast.

This milk-like urine presented the following chemical characters.

A. When exposed to heat, a large and tremulous coagulum of albumen formed, becoming firmer and more solid on raising the temperature to ebullition.

B. About four ounces of the urine were agitated with half an ounce of pure ether, and the mixture set aside in a carefully closed bottle. On the following day the mixture had lost all its opacity, and presented three well-defined layers. The lowest, forming the great bulk of the urine, was transparent, and consisted of urine deprived of the ingredients which had produced its previous opacity. On the surface of this rested a perfectly transparent and tolerably firm coagulum of fibrin, about a quarter of an inch thick, of a pale yellowish colour. The superior layer consisted of an ethereal solution of fatty matter; this fluid was of a fine golden yellow colour.

C. The ethereal solution was decanted and allowed to evaporate spontaneously; a large proportion of yellow fat, closely resembling butter in colour and odour, was left. It differed from some specimens of fatty matter obtained by an analogous process from milky serum of blood, in not presenting any tendency to crystallize. This yellow fat readily fused by heat into a perfectly transparent oil, which slowly solidified by cooling, and it has undergone no change by keeping, up to the present period.

D. A portion of the urine left to itself for some time underwent no further change than the formation of a thin creamy layer on its surface: not the slightest tendency to the formation of a fibrous coagulum appeared.

E. A portion of the milky fluid was evaporated at a boiling temperature to dryness, and digested with hot water. The fluid was filtered, and after concentration, treated with nitric acid, when crystals of nitrate of urea slowly formed.

374. I carefully examined the urine under the microscope, but not the slightest appearance of oil-globules, blood-discs, or pus-granules, could be detected; the opacity appearing, as in the first specimen given me by Mr. Gossett, to depend upon the presence of particles so minute as to present no defined form; appearing like mere irregular points when examined with a linear power of 800 under an excellent achromatic microscope. The result of this examination is completely opposed to the few statements recorded by continental observers on the optical characters of fatty urine. Thus, M. L'Heritier has stated that oily globules can always be detected in fatty urine; and a similar remark was made by the late Dr. Simon, of Berlin. The latter has, indeed, stated that he has met with three varieties of fatty urine; one in which the fat is merely diffused through it, and collects on its surface by repose, as in the cases recorded by Dr. Elliotson: the other in which the fat was combined with albumen; and a third in which the fatty matter existed with casein as an emulsion, forming, in fact, true milky urine. In all these Simon states that fat-globules could be seen by the microscope.

375. This curious state of the urine is epidemic in the Mauritius, and accompanies a form of irritative fever. Mr. Rogers, surgeon to the police establishment in that island,

has been kind enough to put into my possession some information respecting this curious ailment, and I have selected one of the cases he placed in my hands for illustrating this affection as it occurs there.

Madame B—, residing in the Mauritius, nursing an infant six months old, first suffered from dysentery four months previously. On its disappearance in three weeks, she became the subject of fever, pain in the back, sense of weight in the loins, and the secretion of milk quite stopped. The urine gradually became of a light ochre-colour, thick and opaque, like urine mixed with milk. On visiting her, (July 1846), Mr. Rogers found her labouring under severe fever, with thick, full, and hard pulse of 96, the pain in the right lumbar region aggravated by pressure. Bowels confined, but had been acted on by small doses of castor oil. The urine was acid, free from odour, specific gravity 1·015: a microscopic examination discovered it in myriads of minute irregular globular masses. When agitated with ether, the urine soon became clear, a yellow fluid separating and floating on its surface. The urine thus freed from fat, deposited albumen both by heat and nitric acid. After separating the albumen by heat and filtration, the concentrated urine yielded crystals of nitrate of urea on the addition of nitric acid. During this evaporation, the fluid evolved the urinous odour which had been previously absent.

The urine consisted of	Water	943·
”	Matter separated by ether	20·
”	Albumen	6·
”	Urea	23·
”	Extractive matter	2·
”	Saline matter	6·
		1000·

A second specimen was collected a week or two later (July 22), it was less opaque, specific gravity 1·010, acid. It contained an abundance of ovoid particles, about the size of pus-globules, quite smooth, mixed with epithelial cells and blood-discs. Agitated with ether, it separated into three layers by repose, the uppermost was a white woolly matter (coagulated albumen), the next a yellow solution of fat, floating on the now clear urine. By a violent agitation, the two upper layers became mixed and floated on the urine, forming a loose coagulum. The composition of this urine was—

Water	909·4
Matter separated by ether	7·0
Albumen	2·0
Urea, Extractive matter, Salts	81·6
	1000·

A third specimen was obtained August 8th. It was much less milky, pale yellow, specific gravity 1·013, nearly neutral, under the microscope numerous blood-discs were visible, with a few pus-like globules with serrated margins. It consisted of—

Water	963·44
Matter separated by ether	6·00
Albumen	2·00
Urea, Extractive, Salts	28·56
	1000·

376. Dr. Bence Jones, to whose zeal in these inquiries we are so much indebted, has recently published the result of his observations on this form of urine, and I must refer to his papers for a full account of his results. The following, however, are the most important conclusions at which he arrived.

1. The fat on which the milky aspect of the urine depends, appears after the absorption of chyle, but the albumen, fibrin, blood, and alkaline salts, may be found even when no food has been taken, and consequently no chyle formed.

2. During absolute rest, albumen disappears from the urine, and does not reappear in any quantity, even after taking food, unless active exercise is employed. A short time before rising early, the urine gelatinizes by repose, but is free from fat.

3. This state of urine does not depend upon the presence of an excess of fat in the blood, as proved by actual analysis.

4. The seat of this disease is probably some slight alteration in the structure of the kidneys, by which, when the circulation through these organs is most active, one or more of the constituents of the blood exude from the capillaries and escape into the urine.

377. Dr. G. R. Bouyun, of George Town, Demerara, has described some cases of this disease which seems to be often epidemic there, especially among the creoles and negroes. The appearance of the so-called chylous state of the urine appears to be in his cases always accompanied by attacks of irritative fever and emaciation like that of diabetes. Dr. Bouyun is inclined to refer this disease to some lesion of the assimilative functions, and has been successful in curing it by the free administration of a decoction of the Mangrove bark (Rhizophora Raccmosa). This remedy seems to act freely on the skin, increases the secretion and alters the character of the urine, and improves the general health.

URO-STEALITH.

378. A peculiar form of fatty matter has been lately discovered by Dr. Florian Heller,[136] who has described it under the name of uro-stealith. The patient was a weaver, 24 years of age, admitted into the Vienna Hospital, in February, 1844, under the care of Dr. Bittner, for calculus. He laboured under all the symptoms of stone in the bladder, and passed some small concretions, which on examination proved to be composed of a peculiar fatty matter. He was, therefore, treated with carbonate of

potass, in doses of ℨij daily, and in fourteen days he lost nearly all the symptoms for which he entered the hospital.

379. *Diagnosis of uro-stealith.*—When small concretions of this substance are passed, they may be recognised by the following characters. When fresh, they are soft, becoming, when dry, hard, yellow, wax-like, brittle, and amorphous; and by transmitted light, presenting a greenish-yellow colour. By heat, this substance melts, puffs up, inflames, emitting a peculiar pungent odour between that of shell-lac and benzoin, and leaving a voluminous ash. In hot water it softens, but does not dissolve; slightly soluble in alcohol, readily in ether; the latter solution, on evaporation, leaves a residue, which assumes a violet colour by a gentle heat. Nitric acid dissolves it with slight effervescence, forming a colourless substance.

380. *Characters of the urine.*—The urine, in the only case in which uro-stealith has been hitherto found, was quite destitute of uric acid, but contained 12·63 grains of urea in 1000 of urine, was quite neutral, contained an abnormally large proportion of chloride of sodium, and deposited crystals of triple phosphate mixed with fat-globules. Specific gravity 1·017, inodorous, colour light yellow and whey-like. It was not rendered turbid by nitric acid. After the administration of the alkaline carbonate to this patient, the fatty matter appeared in the urine completely saponified, and then the addition of ammonia, which previously scarcely affected the urine, produced a reddish-brown colour.

381. *Pathological indications.*—Unknown, from our experience being limited to the single case here related. The successful treatment by carbonate of potass will be a useful hint as to the treatment to be persued if another case should fall under our notice.

CHAPTER XIII.

REMARKS ON THE THERAPEUTICAL EMPLOYMENT OF REMEDIES INFLUENCING THE FUNCTIONS OF THE KIDNEYS.

Assumed capricious influence of these remedies, 382—First law regulating them, 383—Apparent exception to, 384—Second law, 385—Conditions for the entrance of the remedy into circulation, 386—Time required for absorption of salts, 387—For decomposition, 388—Illustrated in alkaline salts, 389—In mineral waters, 389—Diuresis opposed by irritable gastro-intestinal mucous membrane, 391—By obstructive diseases of the heart or liver, 392—Dr. Barlow's researches, 393—Applied to the explanation of irregular action of remedies, 394—Practical conclusions, 395.

382. It has been long stated by writers on therapeutics, and as generally admitted by the profession, that few remedies are so capricious in their action as those which directly or indirectly influence the functions of the kidneys. In some patients, a diuretic effect being obtained by the first remedy prescribed in a most satisfactory manner; whilst in other, apparently parallel cases, all medicines have failed in stimulating the secreting functions of the renal capillaries. When we refer to the writings of authors on this subject, we find the remedies which are supposed to excite the urinary secre-

tion arranged according to their presumed modes of action; and although there is always included a class of *direct* diuretics, or, in other words, of drugs which are supposed really to reach the capillary circulation of the kidneys, and stimulate the vessels by actual contact: yet daily experience proves that even these, too frequently, entirely fail in exciting the medicinal influence which has been accredited to them.

As much importance has been attributed, in the preceding pages, to the impregnation of the urine with solvents for deposits, so as to prevent the formation of a concretion, it becomes a matter of especial interest to devote a little space to the consideration of the question, whether by any means we can ensure the exertion of a therapeutical effect upon the secreting functions of the kidneys, and whether the apparently uncertain results of our diuretics and other analogous remedies are really as capricious as has been supposed. In a word, whether it is not in almost every case possible to predict, with tolerable certainty, from the knowledge of a few general laws, what will really be the effect of a remedy destined to act upon the kidneys.

383. To save any unnecessary circumlocution, I may be permitted to state that I take it for granted that independently of absorption by the lymphatics, fluids can find their way into the various capillaries by direct imbibition: and further, that living membrane is obedient, *quoad* imbibition and exudation, or endosmosis and exosmosis to the same physical laws as when dead and removed from the body. A consideration of facts recorded by observers of credit in all modern works on physiology[114] will afford ample data for admitting these several assumptions. It will then be necessary to con-

sider, *seriatim*, the laws which appear to be fairly reducible from recorded experience.

LAW 1st.—*All therapeutical agents intended to reach the kidneys must either be in solution when administered, or capable of being dissolved in the fluids, contained in the stomach or small intestines, after being swallowed.*

No one in the present state of physiological science can dissent from this law; not the slightest evidence exists of the kidneys ever allowing a body not in solution to pass their capillaries without positive breach of surface. It has, indeed, been stated that metastatic discharges of pus have occurred from the kidneys; that the purulent effusion of an empyema has been absorbed, and finally excreted, by those organs. Such statements, however, admit, as we have already seen, of a much more direct explanation. The capillary and lymphatic vessels can be readily submitted to microscopic examination, and no visible pores can be detected in their walls. How then is it possible that organized cells, consisting each of an investing granular membrane, with several distinct nuclei, can find their way through the walls of a vessel in which no visible pores can be detected, and permeate, without breach of surface, other capillary vessels in the kidney similarly organized? In the same way, it has been loosely said, that exudations of blood-corpuscles occur from the renal vessels in some cases of hæmaturia. To this statement a similar objection applies. All experience goes to prove that no escape of blood-corpuscles or pus-particles can possibly occur from a capillary without

actual solution of continuity. Where urine really contains hæmatosine without actual lesion of vessels, the corpuscles must have burst in the capillaries, and allowed the oozing out of their contents, as often occurs in purpura and scurvy. The researches of Wöhler[115] have proved to a demonstration that for a body to be excreted by the kidneys it must be actually in solution, and indeed they have shown that the function of these organs is strictly limited to the elimination alone of substances in solution.

384. I am quite aware that an objection may be urged against these conclusions, founded on the presumed metastasis of purulent formations from their original seat and their subsequent deposition in the structure of distant organs, especially of the liver. To the majority of such cases, when really accredited and free from fallacy, the co-existing presence of phlebitis will generally afford a sufficient answer. In some rarer cases, pus may escape from a deep-seated abscess by ulceration into a blood-vessel. In either case, if the pus-particles enter the current of the circulation, they would be hurried along with it; to be entangled in the capillary ramifications through which their size presents an insuperable obstacle to their escaping. Still, although such cases are by no means sufficiently numerous, nor in many instances sufficiently accredited, yet we are not justified in refusing to admit the possibility of a purulent deposit being occasionally absorbed. But this admission by no means implies that the pus-particles really enter the vascular system from the sac of the abscess. The process of absorption here is almost indubitably one of metamorphosis, by which the elements of the pus are partly re-arranged to constitute a soluble compound. The presence of oxygen, or saline matters,

or of an alkaline salt, conveyed in the arterial blood, will be amply sufficient to explain this reduction of the pus-particle to *a soluble form* without supposing its ultimate metamorphic change into the elements of bile and urine to occur, as in the case of absorption of muscle (39). The liquor puris of pus contains tritoxide of protein in solution (the pyin of some chemists), and the accession of oxygen would soon be able to convert the solid pus-particles into a similar state, whilst the action of salts and alkalies in breaking up the particle has been before explained (328). Pus thus dissolved and absorbed may readily be deposited in its original form by the removal of its solvent, and thus we are enabled to avoid admitting the necessity of a nearly physical impossibility, viz., the absorption of a pus-particle through the parietes of a vein or absorbent.

LAW 2d.—*Bodies intended to reach the kidneys must to ensure their absorption, have their solutions so diluted as to be of considerably lower density than either the liquor sanguinis, or serum of blood* (i. e. *below* 1·028).

385. Peculiar attention to this important law has been directed by the published remarks of Professor Liebig already referred to. It is founded upon the well-known phenomena described by Dutrochet,[116] under the terms of endosmosis and exosmosis, or imbibition and exudation. They may be thus briefly described. Let a glass tube, open at both extremities, have a piece of animal membrane, as bladder, &c., tied firmly over one end. Partly fill the tube with syrup, and immerse it in a glass of distilled water. In a short time the fluid will

rise in the tube, the water having permeated the membrane and diluted the syrup; this is an example of imbibition or endosmosis. Empty the tube, partly fill it with water, and immerse it in syrup; the fluid will now fall in the tube, exuding through the membrane, and diluting the syrup in the external vessel by exosmosis. As a general law, it may, as far as living tissue be concerned, be sufficient to state that when two different fluids capable of mixture, be separated by an animal membrane, the fluid lowest in specific gravity, will permeate the membrane, to dilute the denser fluid. In dead animal membrane, whilst imbibition goes on, a certain amount of exudation occurs, but to a much smaller extent, and *vice versâ*; whether this also occurs in living tissue there are no facts before us to enable us to decide.

386. When, therefore, saline substances, especially, are intended to be absorbed and ultimately to reach the kidneys, it is necessary that the density of their solutions should be much below 1·028; the proportion of solids dissolved in the aqueous vehicles prescribed being always less than five per cent. Daily experience in the employment of remedies will show the importance of this law in a therapeutical sense. Thus, a tolerably strong solution of the tartrate, or acetate of potass, will altogether escape the absorbents; indeed, so far from being imbibed by the capillaries, it will actually excite an exudation of water from these vessels in the stomach and small intestines, thus becoming diluted by exosmosis, and a sensation of thirst is excited, by which the patient is compelled to drink for the purpose of supplying the water removed from the blood by exudation. In strong solutions, the salts alluded to stimulate the bowels and purge. They are, moreover, said to act as *hydragogue* purgatives, pro-

ducing watery motions,—a fact also capable of ready explanation on physical laws; exudation of water from the exhalents (capillaries) occurring, on account of the density of the saline solution traversing the intestines, just as exosmosis was produced in the experiment of the tube of water immersed in syrup. We can hence readily perceive why half an ounce of acetate or tartrate of potass will purge, and a scruple of either excite diuresis. This statement has been lately called in question by Mr. F. W. Headland, in his elaborate and valuable Essay on the 'Action of Medicines' (a work none can read without instruction), but a long and careful observation has quite convinced me of its accuracy and practical importance.

387. The rapidity with which even properly adjusted doses of saline bodies reach the urine is liable to great variation from many causes, but from none more than from the influence of the preceding meal. As a general rule, the substance finds its way to the kidneys with the greatest rapidity when the stomach is empty. Some very interesting experiments, performed by Mr. Erichsen,[130] throw great light on this subject. This gentleman had under his care a lad who had been the subject of congenital extroversion of the bladder; the abdominal parietes and anterior wall of the bladder being deficient above the pubes to a considerable extent, so that the orifices of the ureters were visible. On ten different occasions a solution of ferrocyanide of potassium was given to this lad, and the urine carefully allowed to drop from the ureters into a solution of sulphate of iron, so that the instant at which the salt appeared in the urine it was readily detected. The following table shows the results of the experiments:

When last meal taken.	*Time required for the detection of the salt in the urine.*
2 minutes	27 minutes
2 "	39 "
24 "	16 "
1 hour	14 "
1½ "	6½ "
2 "	12 "
4 "	2 "
4½ "	2½ "
11 "	1 "
11½ "	2 "

388. When alkaline citrates and tartrates were administered, the time required for their appearing as carbonates (162) in the urine was found to vary considerably. This admits of a ready explanation, not only in the influence of the previous meal, but in the perfection at the time of the process of assimilation. For, as has been already stated, the salts of vegetable acids undergo decomposition only when the digestive functions are in a state of tolerable integrity, escaping metamorphosis when the assimilating powers are much depressed. Mr. Erischen obtained the following results in his experiments on this patient:

Time since the last meal.	*Salt given.*	*Time elapsing before the occurrence of an alkaline condition of the urine.*
3½ hours	Citrate of soda	28 minutes.
5 "	Citrate of potass	40 "
12 "	Tartrate of soda	34 "
2 "	Ditto	47 "

In the first two of these experiments the urine remained alkaline for several days after the administration of the salts.

389. These facts are of the utmost importauce to the

success of our practice in the treatment of uric acid deposits, or gravel, by saline remedies, especially by phosphate of soda. This salt readily finds its way into the kidneys when administered in a diluted solution; but if prescribed in a saturated solution or in large quantities, it, like the tartrate and acetate of potass, excites exosmosis instead of endosmosis, and acts as a mild hydragogue cathartic. A similar remark applies to the majority of salts, of alkalies, and of earths. Most neutral salts are therefore diuretic, if properly administered so as to insure their absorption into the circulation; once being absorbed, it is the duty of the kidneys to filter them off from the blood, and hence they exert a diuretic influence, merely by giving the kidneys an extra amount of work to perform.

390. All the natural waters are diuretic, and if drunk in equal quantities are nearly so in the ratio of their levity and consequent purity. Thus the nearly pure water of the Malvern springs, rapidly and readily enters the blood by endosmosis, and escapes by the kidneys, whilst sea-water in equal doses causes the exosmosis of water from the intestinal capillaries; hence exciting thirst and purging with fluid motions, scarcely inducing any diuretic action. On the contrary, sea-water, like all moderately strong saline solutions, diminishes the bulk of the urine, and causes it to escape in a more concentrated form, simply from its inducing an efflux of water from the blood through the walls of the capillaries of the intestines, which would otherwise have escaped by the capillaries of the kidney.

391. In diseases in which an extremely irritable condition of the gastro-intestinal mucous membrane exists, diuresis is often excited with great difficulty, and it is scarcely possible to cause any remedy to reach the urine

by direct absorption. Where there is any considerable diarrhœa, and copious watery motions are excreted from the bowels, the urine is always scanty and high-coloured, a condition necessarily arising from its concentration; water freely exuding through the intestines from the blood, and hence but little is left to escape by the kidneys. An extreme instance of this state of things is found in malignant cholera; here, water is so rapidly pumped off, through the intestinal exhalents, that the blood is left absolutely viscid and thick. Hence the nitrogenized elements, which it is the duty of the kidneys to excrete, cannot be removed by the intestines in consequence of the escape of the water which would normally have washed them from the circulation; and the patient dies from a retention of a poison in his system, which the kidneys are unable to remove.

392. The laws just illustrated must be regarded as obtaining only when the entrance of water into the capillaries of the intestines is unobstructed; and when no serious obstacle presents itself to the transit of the water with the blood from the intestinal capillaries to the vena porta, through the liver to the ascending cava, thence through the lungs and heart to the aorta, and finally to the emulgent arteries. When any obstacle materially interferes with the route thus taken by the blood, in any part of its course, a smaller supply of water must reach the kidneys, and the urine will become diminished in bulk and increased in density. To take a familiar illustration, a patient labours under a contracted condition of either of the auriculo-ventricular openings of the heart, and dropsical effusions occur. In consequence of the impediment opposed to the current of blood, the kidneys excrete but a small quantity of urine. The very dropsical effusions may be regarded as a sort of

vicarious effort to relieve the congested state of the veins by allowing the watery elements of the blood to filter through the walls of the smaller vessels. Again, if a patient has a cirrhose or hobnail condition of the liver, the portal circulation will be materially obstructed, and some effects analogous to those produced by a contracted ventricular orifice are the result, viz., dropsical effusions and diminished secretion of urine. In cases of this kind, no benefit can accrue from goading the kidneys by diuretics, unless the obstruction can possibly be lessened or removed. They may be irritated by stimulants like cantharides, copaiba, or squills, until congestion or something worse occurs, without increasing the secretion of urine, simply because the fluid elements are prevented reaching the kidneys. In cases of this kind, the physician at once sees that all direct diuretics are comparatively useless, and he wisely endeavours to remove the dropsical effusion by remedies which, like elaterium, exert a hydragogic action on the intestines.

393. The attention of the profession has been especially drawn to these conditions by the researches of my friend and colleague, Dr. Barlow. He has, moreover, announced the very interesting fact, that whenever a stricture or other obstruction exists in the course of the small intestines, sufficient to prevent fluids readily passing along them, the urine will be diminished in bulk in the direct ratio of the proximity of the obstruction to the pylorus; nearly absolute suppression of urine occurring when the stricture is so high up as to allow but a small quantity of the fluid contents of the intestines to be exposed to the absorbing influence of the portal capillaries. So absolutely does this obtain, that the observation of the bulk of urine secreted has been proposed by Dr. Barlow as a means of diagnosticating the

seat of obstruction in cases of insuperable constipation. The proposition laid down by the discoverer of these facts may properly be assumed for a third law governing the influence of remedies intended to excite the action of the kidneys. I give it in Dr. Barlow's own words.

LAW 3d. "*If a sufficient quantity of water cannot be received into the small intestines, or the circuit through the portal system in the vena cava ascendens, or thence through the lungs and heart into the systemic circulation, be obstructed, or if there be extensive disorganization of the kidneys, the due secretion of urine cannot be effected.*"

394. I think, then, that the so-called capricious effects of most diuretics, or the entrance of any remedy into the renal circulation, may all be explained by one or other of the foregoing laws, and that the supposed uncertainty attending their action is, in most instances, to be traced rather to a want of discrimination on the part of the practitioner, than to any fault in the remedy. An example or two of this kind will be sufficient. Bitartrate of potass is regarded as a diuretic; if a drachm of it be administered with a little fluid, or in a confection, it irritates the intestines, produces fluid motions, and the kidneys are scarcely affected. Let the same quantity of the drug be dissolved in water and then given; it is imbibed by the capillaries, and causes an increased excretion of water by the kidneys, in accordance with the first law. Sufficient examples of the second law have been given already. Of the third we have an excellent illustration in the action of mercury and other cholitic drugs in "directing," as it has been

termed, the action of a diuretic. Thus let us suppose we are called to a patient in whom a sluggish state of the portal circulation exists, the liver being congested or even myristicated, and from some dropsical effusion, or other symptoms, we are anxious to stimulate the action of the kidneys. It is notorious that in these cases the acetate of potass, nitric ether, squill, and other active diuretics, may be prescribed in vain; but as soon as moderately frequently repeated small doses of pil. hydrargyri, or hydrarg. c. creta, or even aloetic remedies, have been administered, and the liver disgorged of its contents by a free secretion of bile, the kidneys begin to act as the almost necessary result of a readier circulation of portal blood. Experience has shown that there is perhaps no diuretic so valuable in dropsy connected with congested or even contracted liver, as a combination of the squill with a little blue-pill. Many remedies regarded as diuretic, probably really act in this manner; thus colchicum appears to influence the secretion of urine by its stimulating the mucous membrane of the duodenum, and thus by irritating the orifice of the common choledic duct, produces an increased secretion of bile and pancreatic juice, and indirectly relieves a loaded state of liver. Taraxacum, a popular cholagogue, owes its diuretic action, in all probability, to a similar cause. Aloes in small doses, and other remedies, may be referred to this category.

Again, in heart-disease, especially when from a contracted mitral orifice, or from dilatation of the organ, a loss of relation between its cavities and their orifices exists, and dropsy results, the exhibition of stimulant diuretics is nearly valueless. Here, the guarded employment of the infusion of digitalis, by soothing the irritability of the heart, and calming the irregular

circulation, virtually diminishes the congested state of the vascular system, and acts indirectly as an excellent and efficient diuretic.*

395. From the above observations the following practical conclusions may be drawn—

> 1. Whenever it is desirable to impregnate the urine with a salt, or to excite diuresis by a saline combination, it must be exhibited in solution, so diluted as to contain less than five per cent. of the remedy, or not more than about twenty-five grains in an ordinary draught. The absorption of the drug into the capillaries will be ensured by a copious draught of water, or any diluent, immediately after each dose.
>
> 2. When the urine contains purpurine (187), or presents other evidence of portal obstruction, the diuretics or other remedies employed should be preceded or accompanied by the administration of mild mercurials, — taraxacum, hydrochlorate of ammonia, or other cholitic remedies. By these means, or by local depletion, especially by leeches to the anus, the portal vessels will be unloaded, and a free passage obtained to the general circulation.
>
> 3. In cases of valvular or other obstructions

* I cannot avoid alluding to the extreme value of a combination of iron with this important drug, in the dropsical effusion arising from contracted mitral orifice. The benefit resulting from tinct. ferri sesqui-chloridi, ♏xv, with infusi digitalis, ℥ij, every five or six hours, the bowels being kept freely acting, is really very remarkable. This combination of a *direct* sedative with the *hæmatic* tonic is not so unphilosophical as may at first sight appear. The digitalis obviously allays the morbid irritability of the diseased organ, whilst the iron supports the vital powers, and enables the blood to act as a healthier stimulant to the heart itself.

existing in the heart and large vessels, it is next to useless to endeavour to excite diuretic action, or appeal to the kidneys by remedies intended to be excreted by them. The best diuretic will in such cases be found in whatever tends to diminish the congested state of the vascular system, and to moderate the action of the heart; as digitalis, colchicum, and other sedatives, with mild mercurials.

CHAPTER XIV.

BLOOD DEPURATION BY THE KIDNEYS AS A REMEDY IN DISEASE.

Blood depuration by the kidneys, 396—Crisis by urine, 397—Elimination of poisons, 398—Evidence of blood depurations in ague, 399, 340—In acute rheumatism, 402—Aided by remedies, 403—Diuretics, 404—Renal hydragogues, 405—Renal depurants, 406—Their influence in disease, 408—Persistence of miasmatic poison, 409—Therapeutical value of acetate of potass, 410—In conjunction with mercurials in ague, 411—Successful treatment of rheumatism by the acetate, 413—Use of nitrate of potass, 414—Renal depurants as substitutes for mercurial alterants, 415—Superiority of acetate, citrate, and tartrate, over carbonates of alkalies, 416.

396. Enough has been advanced in the earlier chapters of this work to prove that the functions performed by the kidneys is far more exalted than that popularly assigned to these organs. It is true that they do act as pumps, and remove from the blood a considerable quantity of water (51), and hence the bulk of the fluid they excrete is often most erroneously assumed to be a measure of the perfection of their office. This is, however, as we have seen, but a small part of the renal function (32); and, indeed, by no means in many animals, especially birds, reptiles, and insects, is it even

a necessary one (87). But in all classes of animals, the kidneys, by acting as *blood-depurants*, are ever active in preserving life by removing from the circulating mass, containing, as it does, part of the *sewage* of the body (40, 45), certain matter, which, if retained, would produce, not merely inconvenience, but death. Every animal developes, in his own organism, during the process of metamorphosis of tissue (38), a series of nitrogenized substances, which are, if allowed to accumulate in the blood, as poisonous to it as the deadly secretion of the puff-adder is to a person into whose blood its fatal bite has conveyed it. Hence, although the influence of the skin, the lungs, and the liver, in preserving the blood in a state fit for the nutrition of the body is well recognised, and its importance admitted, we can hardly attribute sufficient consequence to the depurating influence of the kidneys.

397. We have seen how remarkably the kidneys act in depurating the blood of bile when the hepatic functions are impaired (187); and how, by this remarkable *compensation of function*, life is preserved for a very long period after the liver has ceased to excrete anything. We have also noticed the application of Wöhler's law to the function of the kidney, and have seen that the urine holds in solution a very large number of bodies whose retention in the blood would be injurious to health (383), although they generally appear in the excretion in a metamorphosed state; thus benzoic acid, hydruret of salycyle, and sulphuret of potassium, when taken into the stomach, appear in the urine respectively as hippuric acid, salycylic acid, and sulphate of potass.

In the lectures I had the honour of delivering before the Royal College of Physicians, in the spring of 1848, I entered at some length into this subject, especially in

relation to the observations of the old physicians, who watched with the utmost attention the critical changes occurring in disease as evidenced by certain changes in the urine. The *crisis by urine*, indeed, a term as old as the father of physic himself, was always looked for as an indication of the depuration of the blood from the "deleterium quid," which was assumed to be, by acting as a ferment, the exciting cause of disease. Indeed, the modern zymotic theory of disease is but the revived hypothesis of Sydenham, Morton, Willis, and their contemporaries, and the study of the works of the latter physician especially are of great interest in connection with this subject. I am quite aware that many, in common with myself, have often wondered that this *crisis by urine* was so seldom discovered now, at the bedside, especially in cases of fever. But this does, I think, admit of some explanation; for on referring to the history of fevers earlier than the last century, it is impossible to avoid noticing the remarkable tendency to well-marked periodicity, they all exhibit. It might, indeed, almost be doubted whether a genuine continued fever was ever then met with. The greater prevalence of malaria and marsh-miasm in this country, from the existence of larger tracts of unreclaimed and undrained marshes, will, to some extent, explain the marked periodicity then observed in fever. That a critical change in the urine (by which I mean a change synchronous with alterations in the phase of disease) does exist in periodical fevers or agues, and can readily be detected, has been, I hope, sufficiently proved in the lectures referred to.

398. It is hardly necessary to say that I do not mean to assert that the *materies morbi* does escape by the kidneys unchanged, and that these organs can really separate from the blood the actual miasmatic poison of

ague or other zymotic disease. But I am anxious to express my belief in our being able by remedies to decompose, or modify such poison, and enable the kidneys to remove it in a metamorphosed state. We have, however, some evidence that certain organic matters easily decomposed, are really occasionally excreted from the kidneys unchanged; thus quinine, daturine, and some other of the vegetable alkaloids are thus carried off in the urine. The Kamschatdale debauch on the Amanita muscaria is a good illustration of the kidneys receiving a poison from the blood unchanged. A party of men will eat this fungus and luxuriate in the sensual excitement of its intoxicating influence, and when this has passed off, the further supply of Amanita being exhausted, they can keep up the revel by drinking the urine they excrete.

399. In watching disease, we must not hope to obtain evidence of critical depuration of the blood by merely looking at the urine. This can alone be detected by carefully collecting the urine of each twenty-four hours, measuring, and taking the specific gravity of the whole. Then, as we have already seen, a close approximation to the amount of solids contained in the urine can be obtained by a single calculation (59). From a very careful set of observations carried on during several years in the wards of Guy's Hospital, in which I have been aided most zealously by my clinical reporters for the time, we have determined the fact, that in every case of ague, a remarkable relation was observed to exist between the accession of each paroxysm, and the diminished excretion of solids in the urine, and consequently less perfect depuration of blood. The following cases, being two of the earlier ones on which this observation was made, will illustrate this statement; they were reported by Dr. Robert Finch, now of Greenwich—

Owen S—, æt. 27, by occupation a bricklayer's labourer, admitted into Lazarus ward, May 21st, 1845, under Dr. Golding Bird. His last residence was at Bankside; before that, for some time at Gravesend. Previous health good; said that he had lived temperately, and once suffered from syphilis.

Five months ago, at Gravesend, he first had a shivering fit, followed by the usual hot and sweating stages; he entered Guy's Hospital, under the care of Dr. Barlow, and left in three weeks well. On April 1st, the first attack appeared rather irregular in its stages, and, to use his own expression, he did not "shake out." The paroxysm returned every alternate day, at about three o'clock in the afternoon. In the previous illness they appeared at noon.

On admission, aspect sallow and melancholic; complained of frequent giddiness, with a sensation of dulness and stupor. Abdomen flatulent, painless; no appetite; bowels confined; tongue clean and moist. No evidence of enlarged spleen or liver. Urine, sp. gr. 1·028, depositing pink urates, and containing a little biliary colouring matter, but no albumen.

Hyd. c. Creta, Ipecacuanhæ, āā. gr. j; Ext. Conii, gr. iij, t. d. s.

May 22d.—Had a paroxysm yesterday at 3 o'clock, lasting about four hours; complained of "cold creeping" down his back.—P.

23d.—A paroxysm at 3 a.m., lasting not much more than two hours; bowels act freely; dejections pale.—P.

24th.—Felt better; in good spirits.—P.

27th.—No return of ague; aspect improved and less sallow; urine depositing urates, stained pink with purpurine; bowels acted freely; skin rather hot and inactive.—P.

29th.—Improving in health and spirits; complained of shivering between the scapula. Urine pink from purpurine, but not letting fall a deposit.

Beeberinæ Sulphatis, gr. j, ter in die.

June 2d.—Yesterday at noon had a severe paroxysm; shivered severely for three hours, followed by a long and severe hot and sweating stage; bowels confined for two days.—P.

Pil. Cal. c. Hyd. iij, hâc nocte.

3d.—Another paroxysm, but not so severe; urine alkaline.

Beeberinæ Sulphatis, gr. j; Pil. Hyd., gr. j, t. d. s.

5th.—Another attack this morning; urine acid; perspiration neutral.—P.

7th.—Quite well yesterday; this morning had a slight shivering at 10 a.m., but no hot and sweating stage; seemed dull and stupid.

Beeberinæ Sulphatis, gr. j, ter in die.

10th.—No return of ague; appetite good.—P.

13th.—Progressing favorably; had a healthy tint of the whole surface of the body.

16th.—Complained of a little giddiness, otherwise quite well.

17th.—Convalescent. Made an out-patient, and remained free from ague as long as he was kept under notice.

The following is a tabular view of the examination of the urine of this patient.

Date.	Fluid ounces of urine in 24 hours.	Specific Gravity.	Action on Litmus.	Weight of solids present in grains.
May 23	12	1·028	Acid, pink deposits	352
„ 26	40	1·020	„	828
„ 28	35	1·020	Acid, no deposit	725
„ 30	48	1·020	„	1054
„ 31	45	1·016	„	743
June 2	35	1·014	Alkaline	514
„ 4	30	1·028	Acid, pink deposits	879
„ 6	27	1·034	„	1036
„ 7	35	1·013	Acid, no deposit	436
„ 9	40	1·028	„	1172
„ 11	45	1·016	„	742
„ 13	40	1·022	„	916
„ 14	43	1·022	„	984
„ 16	37	1·027	„	1044

The proportion of solids excreted in a given time, is calculated from the specific gravity, according to the table before alluded to, and therefore must be regarded as approximately, not absolutely, correct (59).

400. In this case we had to treat a patient who had been long immersed in malaria, who had suffered from a previous attack of ague, and whose portal circulation was interfered with. Although no enlargement of the liver or spleen could be detected by "palpation," still the jaundiced urine and sallow miasmatic melancholic aspect sufficiently attested the torpid mode in which the liver was carrying on its functions.

On looking to the table of the urine, it must be admitted that there exists, to say the least, some curious coincidence between the free action of the kidneys, *quoad* the excretion of solids, and the improvement of the patient. The unusually large quantity of solid constituents removed by the kidneys of this patient is remarkable, and certainly very unfrequent. Whether this was owing to any idiosyncracy, I have no means of knowing.

On referring to the table, we find that on May 23d, but 352 grains of solids were removed by the kidneys in twenty-four hours; the patient's disease not having then shown any tendency to yield to our remedies, and bile existed in the urine; the quantity of solids increased to the 30th, on which day it reached the remarkable quantity of 1054 grains; on the 31st, it suddenly fell to 743 grains; and in the succeeding twenty-four hours, the paroxysm, absent for several days, returned. On the following day, June 2d, the urine was alkaline for the first time, and contained less than half the quantity of solids which existed four days previously, and he had a most severe attack on the next day; the kidneys became more active, and a less severe attack appeared on the 7th, when the solids again fell to a minimum; after this time they were again copiously excreted, and the ague finally vanished.

Mary H——, æt. 13 years, admitted May 23d, 1845, into Martha ward, under Dr. Golding Bird. She was born at Sheerness, and had lately re-

moved to Deptford; had scarcely suffered from any illness before the present one. Although well developed for her age she had never menstruated.

Three years ago she first suffered from ague of the quartan type, two clear days elapsing between the attacks; the paroxysm then commencing at noon, and appearing pretty regularly in spite of treatment for two years. She then left Sheerness, and came to Deptford, and shortly after attended Guy's Hospital, as an out-patient, under Dr. G. Bird. She was cupped over the spleen, and took quinine, so that in a month she appeared cured, and remained well for eight months. Lately she had become emaciated; a month ago, ague again appeared; still quartan in type.

On admission, the skin was active, although cold; aspect not very sallow, but dull and stupid; pulse quick, although small and regular; no appetite; complained of thirst, and occasional bilious vomitings. There was considerable pain across the forehead, and from her mother's account she was light-headed at night. On examining the abdomen, the spleen could be felt decidedly enlarged. Urine stated to be high-coloured during the paroxysms; pale in the intermissions.

May 24th.—Had a paroxysm to-day, lasting from noon to six in the evening.

Hyd. c. Creta, gr. ij; Ipecac., gr. j, ter in die.

27th.—Paroxysm came on at noon, as usual, and continued seven hours.

Beeberinæ Sulphatis, gr. j, 4ta quaque horâ.

Paroxysms absent.

29th.—Pretty well, but the skin hot and dry.—P.

31st.—No ague yesterday: skin acting freely; bowels confined.

Rep. Beeberinæ Sulphatis.

Pil. Hydrarg., gr. iij; Ex. Coloc. Co., gr. vj, alt. nocte.

June 3d.—No return of ague; too much heat of skin; the tongue had a white fur with elongated marginal papillæ (strawberry tongue).

Augeatur dosis Beeberinæ ad gr. ij.

7th.—Going on well; tongue the same; cheeks flushed, but skin perspirable.—P.

14th.—Progressing favorably during the week; the tongue had cleaned. She seemed very well.—P.

17th.—Not so well; some gastric disturbance, owing to some irregularity in food.

Zinci Sulphatis, ℈j, statim.

20th.—Was well after the emetic.

27th.—Convalescent.

The following table presents a view of the patient's urine whilst under treatment:—

Date.	Fluid ounces in 24 hours.	Specific Gravity.	Action on Litmus.	Weight of solids in grains.
May 24	35	1·008	Acid	280
,, 26	28	1·013	,,	375
,, 28	26	1·020	,,	538
,, 30	25	1·024	,,	625
,, 31	20	1·022	,,	458
June 2	30	1·017	,,	528
,, 6	35	1·018	Alkaline	651
,, 7	30	1·020	Acid	621

A glance at this table shows that *pari passu* with the patient's improvement, a gradual increase occurred in the solids excreted by the kidneys. No ague appeared after the blood had been depurated of 538 grains of effete matter, on the 28th of May. In this case, unlike the last, although the patient had long been exposed to the poison of marsh malaria, she did not suffer any relapse, and she remained well during two years, when she again came under my care as an out-patient, with a very slight attack of ague.

401. I hope that I shall not be misunderstood in the line of argument I have adopted. Although believing

most completely that ague is primarily excited by the influence of a peculiar septic poison derived from marsh malaria, I do not for a moment assert that this particular poison is excreted in the urine during the recovery of the patient (398). The great influence of the malarious poison is in all probability essentially and primarily exerted upon the nervous system, especially on the organic or ganglionic structures, which preside so importantly over the function of secretion. Thus, all the secretions elaborated in the body become affected; and, as is well known, a remarkable tendency to congestion is observed in the portal circulation destined most particularly for the depuration of matters rich in carbon. There can be no doubt that the unhealthy secretions thus formed, become active agents in keeping up in the body the impression of the disease. One of the great elements of successful treatment must of necessity be the depuration of the blood, and thus, by freeing the system from the depressing influence of these vitiated matters, allow the vital powers to throw off the influence of the poison which for a time oppressed them. The influence of small doses of mercury in the treatment of ague is well known; by a gentle but persistent appeal of this kind to the liver, the patient is immensely relieved, and his ultimate cure expedited. Contemporaneously with this, the aspect generally becomes less sallow, a sufficient indication of the liver becoming active in depurating the blood of carbon. Then, under the influence of that very curious class of remedies, the anti-periodic tonics, the paroxysms become less, or quite vanish, whilst ample evidence is afforded of the kidneys performing the important duty of filtering from the blood highly nitrogenized substances, in the rapidly increasing amount of solids existing in the urine.

402. It is not in ague alone that this remarkable critical increase in the excreted solids of the urine is observed; the same thing is, if possible, still more marked in cases of some other diseases, especially acute rheumatism. In every case of this affection in which the urine was carefully collected, and the quantity of the contained solids calculated, we invariably found that whenever the patient improved, the quantity of solid urinary excreta steadily and considerably increased; any relapse being attended with as remarkable a diminution. These observations were neither small in number, nor hastily made; they extended over several years, and amounted to upwards of four hundred in different diseases.

403. Having thus accumulated sufficient evidence to prove that the old idea of the washing away a *materies morti* from the blood by the urine was at least based on truth, the next question for consideration was how far it were possible to aid this function of blood-depuration; and thus, by expediting the removal of noxious matters from the system, hasten the cure of the patient. That we do possess such means I am as convinced as I am of the existence of the function of blood-depuration itself, but before alluding to the proposed plan for effecting this, it is requisite to point out a very important distinction to be made in the different remedies commonly employed to stimulate the kidneys.

404. The class of direct diuretics, therapeutically distinguished from those which act indirectly, by modifying the supply of blood to the kidneys, or by otherwise influencing the capillary circulation in these organs, although limited to remedies which are supposed to stimulate the structure of the kidneys by actual contact, contain nevertheless a very heterogeneous collection of substances.

Thus cantharides and nitrate of potass are both regarded as direct diuretics, and yet their influence is really of the most opposite kind. In a word, some diuretics are alone active in increasing, nearly exclusively, the water discharged by the kidneys; whilst others, as I have proved I hope beyond all doubt, increase the excretion of solids from the blood. Even independently of any chemical explanation of this difference of their action, the researches of Mr. Bowman enable us to suggest a probable physiological solution of this curious fact, by supposing that the vascular tufts of the kidneys are especially stimulated by one series of diuretics to induce the exudation of more water from the blood, whilst the other series especially increase the formation of epithelial structure.

405. With the value of ordinary diuretics, or *renal hydragogues* every practitioner is familiar, their utility in carrying off undue accumulations of fluid in the system is well-known and appreciated. But I am anxious to claim for the depurating or chemical diuretics, or *renal depurants*, the careful consideration of the physician, believing that they constitute a class of agents now almost completely neglected, and indeed hardly recognised, and yet of the highest value in the treatment of disease.

To the class of renal hydragogues belong all those agents which out of the body exert no chemical effect on animal matter, as squill, copaiba, broom, juniper, guaiac, lytta, &c. All these, in the absence of any opposing cause connected with mechanical obstructions to the free course of the circulation, will, it is well known, increase the discharge of fluid by the kidneys, and become often valuable agents in enabling us to successfully treat dropsical accumulations. If the urine secreted under

the influence of these diuretics be examined, the quantity of solids present will not be found to much exceed the normal quantity, unless a considerable quantity of water or other bland fluid be taken at the same time. After I had fully satisfied myself of the general truth of the facts now mentioned, I was much gratified by meeting with a paper by Professor Kramer,[158] on this subject. He administered to persons in health different diuretic agents, and having collected and analysed the urine secreted, he found the proportion of solids seldom exceeded, and was often rather less than, the normal average; and hence concluded that these agents had no physiological action on the system; at least, so far as the excretion of solids was concerned: "Dass die gewöhnlich sogenannten Diuretica ohne alle physiologische Wirkung sind." I adduce Krahmer's observations in preference to my own, as they were evidently not made under the influence of any preconceived view, as it is evident from his paper that he had no knowledge whatever of the facts I have alluded to. I have calculated the following table from his experiments—

Medicine given.	Solids in the urine of twenty-four hours.	Combustible (animal) matter in.	Saline matters in.
None . .	2·4 ounces.	1·28 ounces.	1·13 ounces.
Juniper . .	2·12 "	0·94 "	1·18 "
Venice turpentine	1·94 "	1·11 "	0·83 "
Squill . .	2·25 "	1·04 "	1·21 "
Digitalis . .	2·45 "	1·28 "	1·17 "
Guaiac . .	2·43 "	1·38 "	1·05 "
Colchicum . .	2·32 "	1·36 "	0·96 "

Remedies, then, which exert no chemical action on organic matter out of the body, appear to be incapable of

augmenting the quantity of solids in the urine, and hence are only of use in increasing the elimination of water,—they may, and do act as renal hydragogues, but not as renal depurants.

406. We have next to notice those remedies among the reputed diuretics which exert the influence I have alluded to, and which, according to my own observation, act as *renal depurants* by increasing the metamorphoses of tissue, and act as depurating agents. This class includes the alkalies, their carbonates, and their salts, with such acids as in the animal economy are capable of being converted into carbonic acid, including the acetates, tartrates, citrates of soda and potass.* These remedies all act alike, actively stimulating the excreting function of the kidneys, and generally augment the bulk of the urine; but they do more, they actually increase the metamorphoses of tissue by, in all probability, a direct chemical action on the elements of worn-out and exhausted tissues, or other matter in the capillary laboratory of the body. It is well known that alkalies and their carbonates readily dissolve albumen out of the body, and even break it up into various secondary products. Thus, digested with an alkali, albumen yields leucine, protid, and erythro-protid (bodies allied to gelatine), formic acid, and other compounds. In like manner casein is broken up into tyrosin, leucine, valerianic acid, and other elements. It is exceedingly probable that some such changes occur in the

* Among these ought to be specially mentioned liquor potassæ, the action of which has been so carefully and ingeniously determined by Dr. Parkes. When given while food is in the stomach, it acts merely as an antacid; but when given on an empty stomach it passes into the blood, facilitates the decomposition of protein compounds, and thus liberates sulphur, which, combining first with oxygen and then with the potass, is eliminated by the kidney, as sulphate of potass.

living organism itself, and we should almost expect to find the chemical diuretics effecting important changes. This I have repeatedly confirmed by absolute experiment. But one illustration, one I have already published, may be taken as an example of the rest. A young lady was for some time under my care, labouring, among other things, under a condition of the orifice of the urethra which prevented her passing water without the aid of a catheter; thus admitting of a very accurate examination of the quantity secreted in twenty-four hours. This, when no medicine was exhibited, was collected and examined; and afterwards three drachms of acetate of potass being administered in the course of twenty-four hours, the urine secreted in that time was collected and analysed. The results are shown in this table:

	Without medicine.	*After ʒiij. pot. acet.*
Quantity of urine in twenty-four hours	f℥xvj.	f℥xlvj.
Specific gravity of	1·025	1·017
Solids in	416 grs.	782 grs.
Uric acid	2·6	3·45
Urea	130·5	202·40
Soluble salts	72·0	248·40
Insoluble salts	21·6	32·25
Organic matters not included in the above	189·3	225·50
	416	782

407. The results of these analyses show that, after deducting the excess in the amount of soluble salts, arising from the conversion of acetate of potass into carbonate in its transit from the stomach to the kidneys; the solids of the urine, separated from the blood under the influence of the chemical diuretic, exceed those excreted without its aid by 190 grains. We further learn

that although a large proportion of matter was metamorphosed into both uric acid and urea after the administration of the acetate, still that the greatest increase was in that mixture of organic products set down as *extractive*, and which, as we have seen, consisted chiefly of creatine, creatinine, uroxanthin, and matter rich in sulphur (103). In the example adduced, not only did the patient lose an excess of 30 ounces of water in twenty-four hours, but she *wasted* to the extent of 190 grains more than if no remedy had been given, and to this extent had the blood been depurated of those elements which yielded easiest to the influence of the alkaline salt. As it cannot be denied that vital force is ever active in opposing the chemical changes to which all living fibres are obnoxious, it is fair to assume that this resistance will increase with the vital endowments of a part, or, in other words, that the elements of our frames, resist chemical influences in the ratio of their vitality. It would follow that such constituents of our bodies as present the greatest departure from health are less highly vitalised, and thus would be expected to yield the easiest to the influence exerted by the alkaline diuretics or renal depurants. As a result of this view, we should expect that when we cause an alkaline carbonate to circulate through the blood, it exerts an influence on the nascent elements of those matters less highly influenced by life, resembling that which it exerts on dead matter, aiding their resolution into substances allied to those produced out of the body, and actually causes the matter to assume so soluble a form as to allow of its ready excretion. This remarkable effect of the alkaline diuretics (although now *demonstrated* by actual experiment, and the results of their chemical influence detected in the stream by which they are washed from the body), was not overlooked by the observing physicians of

former years. It was indeed acted upon by the old physicians—witness the host of apozems, diuretic decoctions, and diet-drinks, in which renal stimulants abound; and let us not shut our eyes to the success of the practice, for unless we deny all credence to the statements of the painstaking practitioners of past times, those who will read their quaint records of cases will learn how generally they succeeded in curing the effects of a *caco-æmia*, an unhealthy blood, as evidenced in various eruptive affections, cellular membranous sores, furunculi, and very many such ailments. It is true that in looking at some of their prescriptions we do not generally observe remedies which have now much confidence placed in them as trustworthy diuretics, but then an important element of their potions is most undoubtedly the water of the decoction employed, not in doses of table-spoonfuls, but, as was common in former days, of pints. A most important truth here demands our attention. It may be said that it is true that if a patient takes a pint or two extra of water he will, supposing that no organic lesion exists, excrete a large bulk of urine, from the necessity there exists for pumping off the excess of diluent partaken of. In this way a pint or two of water becomes a diuretic. This every one's experience will enable him to admit; but what is this, it may be asked, but the mere drawing off of excess of water,—where is the proof of blood-depuration? This proof is afforded by calculating the amount of the solid constituents of the urine. It will then be found that the excess of water does not escape alone, but there is really washed away with it a certain, although not very large quantity, of sold debris. To Edmund Becquerel must be accorded the credit of this observation; and any one may satisfy himself of its accuracy by collecting all the urine he passes in twenty-four hours, and determining

the quantity of solids it contains; and repeating this process next day, while throwing into his system three or four bottles of aerated—the so-called soda—water. This observation affords a key to many of the undoubted cures effected by the use of many of the mineral springs. Some of them are, like that of Malvern, remarkable only for the positive purity of their water—setting aside (what we must never forget) the influence of change of scene and association—the diminution of the wear and tear of mind by relaxation from business: healthy air and exercise, amusement of mind and excitement of renewed hopes, we cannot help recognising in the increased action of the kidneys, exerted by a so-called mineral water—a most important agent. A man labouring under some chronic ailment, which, perhaps, like old rheumatism, is the direct result of unhealthy constitution of the blood, starts for one of the Brunnens or Spas, and with fearful devotion swallows the enormous quantity of ten or fourteen beakers of the warm and bubbling water. In a few minutes he begins to secrete abundance of urine, and is engaged alternately drinking and micturating for part of the morning—active exercise, when possible, being enjoined the whole time. By this exercise the waste of tissue is increased, and the copious water-bibbing positively aids the metamorphosis of tissue, and washes its results from the body.

408. The results of these researches have now been tested by some years' close observation at the bed-side of the sick, as it is obvious that nothing but clinical experience can determine the value of any class of remedies as agents in the treatment of disease. From all that has occurred to me, I can most confidently repeat the statement I ventured to make more than four years ago in my lectures at the College of Physicians—

"I would earnestly beg those who are now doing me the honour of listening to my remarks, to give a careful and steady trial to the *depurating or chemical diuretics*, especially the salts of potass with vegetable acids, when they are called upon to treat a chronic affection in which the exciting cause, or existing disease, depends upon the presence of some product of less vitality or imperfect organization. I fully believe that in many instances such matters will be often found to yield, whether they present themselves as albuminous deposits in glands, furuncular disease of cellular tissue, or incrustations on the skin, as in some of the squamous and tubercular cutaneous diseases. That they will succeed in increasing the waste of matter, is, from my observation, beyond all doubt; that the lowest vitalized matters will yield to the solvent the *readiest* is most probable, and that an important and powerful addition to our supply of therapeutic weapons is certain.

"I am not anxious, so soon after the observation of the fact I have announced, to appeal too soon to the results of my own practice in support of it, as I know full well how deceptive are often the results of experience unless largely extended; and the whole history of medicine is one great commentary on the errors arising from observation on results which the mind of the observer has anticipated—an obedience to those *idola specûs*, against the influence of which Lord Bacon long ago warned us. I will not dare to do more than state that it has occurred to me to see the periodicity of ague broken through, the paroxysms lessened and made more distant, and the sallow dirty aspect of malaria exchanged for the cleaner and brighter complexion of returning health, under the influence of the agents I am advocating. The disease has thus been rendered readily amenable to the subsequent administration of the anti-periodic whose previous influence it had resisted, or, at least, not satisfactorily obeyed. Jaundice, connected with a large, sluggish, congested liver, has certainly better yielded to setting up a complementary function on the parts of the kidneys by a diuretic alterant than by goading the liver with remedies whose influence it refused to obey; and in more than a single instance a strumously enlarged cervical gland has yielded to the persisted use of an analogous remedy even after resisting the iodide of potassium."

409. *In ague*, nothing is more easy, as every one is aware, than to check the paroxysms by means of anti-periodics, especially quinine, and in many cases the patient is really cured by the remedy. But any one who has had an opportunity of seeing much of the effects of marsh miasmata, is perfectly aware that if a patient has

been long exposed to their influence, although paroxysms of ague may be for a time checked with quinine or arsenic, the unhealthy state of the blood is not removed. The sallow aspect—the depressed health—the visceral engorgement—all indicate that the poison remains in the system and is continuing its work, although its influence has been blunted by our remedies. After a time, however, imperfect paroxysms, the "dumb-ague," as they are often graphically called by the patient, appear again, requiring the anti-periodic to check their further development. This is a common history, and many persons are thus not really absolutely freed from miasmatic poison for months or years.

410. I do not claim for the acetate of potass the virtues of an anti-periodic, but I do unhesitatingly declare that it will effect that which quinine and its allies cannot do. It will enter the blood, and as a *nascent* carbonate (possessing a far higher state of "chemical tendency"* than ready formed carbonate of potass) in the capillary net-work of the body aid the metamorphoses and excretion of the unhealthy elements of the blood, and their consequent elimination by the kidneys.

When to a person suffering from the effects of marsh malaria, this drug has been administered to the extent of ʒij in the course of twenty-four hours largely diluted, and continued for two or three weeks; not only is no injury effected by the remedy, but the most marked benefits are observed to result. The patient's skin becomes less dusky, the expression more healthy, the dull aspect of the eyes changed for one of cheerfulness, the engorgement of liver and spleen lessens, and the paroxysms of "dumb-ague" disappear, or merely require a few doses of arsenic for their complete cure, and thus

* 'Medical Gazette,' 1848, vol. i, page 1018.

to effect the complete restoration of the patient. Even in recent tertian ague, in which the paroxysms are well marked and even violent, I have hardly ever administered the acetate of potass without observing a diminution in the intensity of the attacks, and a considerable prolongation of the intermissions. Indeed, when quinine has been administered for the purpose of at once checking the ague fit, the subsequent administration of the acetate will not only prevent a relapse, but greatly improve the patient's general health.

411. Every practitioner is aware of the value of mercurial purgatives, as well as of the administration of small doses of pilula hydrargyri to patients suffering from ague, in consequence of the removal of visceral congestion, and resulting in increased depuration of blood by the liver. But I believe the most successful practice, especially in the treatment of cases of ague which have resisted long courses of anti-periodics, consists in the administration of minute doses of a mild mercurial contemporaneously with the acetate of potass. The following case, taken from one of our clinical report books, will illustrate this:

(*Reported by Mr. Bayes.*)

Patrick L——, æt. 27, admitted into Spare Ward, under Dr. Golding Bird, May 1st, 1850. A muscular, well-proportioned man, of light complexion, a native of Cork, having resided in England during nine years. Always intemperate when earning good wages as a labourer, and sober only when deprived of the means to be otherwise. He scarcely remembered to have been previously ill since childhood. In the preceding August he was employed in harvest-work in the fenny districts of Norfolk and Cambridgeshire, where his wife took ague. In October he went to Woolwich, and was employed in unloading barges, until two months ago; since which he had been similarly engaged at Billingsgate. After being thus constantly exposed to miasmatic influences for nine months, he was attacked, three

weeks ago, with an ague paroxysm, recurring each morning about five o'clock. About a fortnight before admission he had a most violent attack, the shivering in the cold stage was so severe that he was obliged to be held in bed, as he stated, by two men. The hot and sweating stage which followed lasted the whole day. Since then the disease assumed a regular tertian type. During the first twenty-four hours of his residence in the hospital, he passed 58 ounces of urine of specific gravity 1·023. A warm bath was ordered, as his skin was exceedingly dirty, and Pil. Cal. c. Col ij. h. s. s.

May 3d.—Pil. Hydrarg. gr. i.; Ex. Conii, gr. iii. fiat pilula, t. d. s.
Potass. Acetatis, ʒss. ex Mist. Camphoræ, f ℥ij. t. d. s.

During the next four or five days the paroxysms diminished remarkably in severity, and the urine on the 6th, amounted to 72 ounces of 1·018, and on the 9th, to 90 ounces of 1·017. By this time a most remarkable improvement had taken place in his countenance, the malarious aspect having nearly disappeared.

May 13th.—He became as bad as ever, the paroxysm of to-day was more severe than any he had experienced since his admission. On the 15th diarrhœa appeared. It was then discovered that he had been privately supplied with black-pudding, and had voraciously devoured a considerable quantity of this mixture of coagulated blood, fat, and oatmeal. The urine had fallen to 50 ounces of 1·016. A brisk cathartic of calomel and colocynth was ordered, and the acetate of potass to be afterwards continued without any mercurial.

17th.—Very much improved, ague fits much less severe, general health apparently good between the slight paroxysms. Rep. Mist. c. Liq. Potass. Arsenit., ♏ v.

20th.—Ague fits much slighter.

June 2d.—Ague fits absent since last report.

412. The remarkable improvement in the patient's condition, after the use of his remedies for a few days, and the diminution of the paroxysm in intensity before any anti-periodic was given, attracted the attention of all who saw him. Yet his case was by no means so remarkable as that of many others under treatment at the same time. I do not doubt that the arsenic or quinine, if given at first, might have checked the disease, but I am quite sure they could not have effected—which the

other remedies did—the conversion of a sallow, malarious aspect into one of really ruddy health—nor do I believe he would have been left so free from tendency to relapse.

413. It is, however, in that really formidable disease, *acute rheumatism*, a malady which merits the most careful and jealous watching, on account of its too frequently leaving behind disease of the cardiac valves or pericardium, that the effects of the acetate are most remarkable. I would not willingly use language which was not completely compatible with experience, but I do not still hesitate to declare that I have never seen the disease in question yield with so much facility to any other remedy. In the severest cases which have been admitted into the hospital under my care (and I prefer alluding to them in preference to cases in private practice, as they have the advantage of being watched by many, and less chance of error arising in the reports of the progress of the patient), I have seen the cure to be more rapid, and the immediate relief to the patient more marked by the use of the acetate of potass in quantities of half an ounce, administered, largely diluted, in divided doses, in twenty-four hours, than by any other treatment. In three days I have repeatedly found the exquisite pain of the joints nearly absent, the patient comparatively comfortable, and able to bear with greater ease the helpless state in which the still swollen joints place him. In no case has any ill effect followed the use of the remedy, and whilst the cure has been far more expeditious, the ill effects of colchicum and mercury have been avoided. The pain remarkably and suddenly lessens, as soon as the urine becomes alkaline and rises in specific gravity. I can, indeed, unhappily attest my experience in my own person on the marked alleviation and rapid

cessation of the pains of rheumatic fever from the use of the drug, and can gratefully compare its influence with the tedious and painful results of mercurial treatment in a former attack. It is difficult to decide on the comparative immunity from pericarditis in acute rheumatism under particular modes of treatment, but the impression on my mind is very deep, that the tendency to this fearful complication is very much lessened as soon as the urine is rendered alkaline by the acetate. I could quote a large number of cases from our clinical report books to demonstrate the efficacy of this plan of treatment. This would, however, be quite useless, as the above remarks convey all the information I can offer. The treatment being as uncomplicated as possible, the acetate being usually administered in some aromatic water, or what is far more grateful, in plain water, to which a few drops of oil of lemons have been added. The only addition to this treatment has generally been a mercurial laxative if constipation existed, and a full dose of Dover's powder on the first day or two of treatment if the pains be severe. The joints being wrapped in sheets of wadding, a plan I have invariably followed since noticing the comfort it afforded to myself in a severe attack ten years ago.

414. In connection with this subject I would especially draw attention to the undoubted benefit resulting from the treatment of acute rheumatism by large doses of one of our most certain diuretics, nitrate of potass, in doses of ℥ss or ℥j, dissolved in two or three pints of any diluent in the twenty-four hours. An enormous amount of urine replaces the scanty excretion generally noticed, and the cure of the patient is considerably expedited. This practice, really of British origin, has been popular in the Parisian hospitals for some years, and has attracted notice here. My friend Dr. Basham has especially drawn

attention to this practice in a valuable paper read before the Royal Medical and Chirurgical Society. The quantity of solids removed from the system by the nitrate of potass is, however, far less than that which is carried off under the solvent influence of those agents which act more energetically on animal matters. It must not, however, be supposed that nitre, or, indeed, any other of the neutral salts, are destitute of influence. It has been long shown that the salt in question will readily dissolve coagulated albumen and fibrin; and it thus, when circulating in the capillaries, may probably exercise no mean influence in aiding the metamorphosis of tissue.

415. I would most anxiously urge upon my professional brethren the importance of giving a fair and patient trial to the acetate of potass in a large class of ailments where the blood is obviously in an unhealthy state, especially where glandular engorgements and furunculous eruptions exist. Indeed, in many of these forms of chronic indisposition in which there is no evidence of organic mischief, but where the general health is depressed, the face sallow, the urine coloured by purpurine, constituting the condition in which the patient is popularly said to be "bilious," the advantage gained by the use of this remedy is remarkable. Hitherto, whenever a remedy influencing the general health through the capillary circulation is required in chronic disease, we generally fell back upon mercury, indeed, a mercurial and an alterative are nearly convertible terms. Instead, then, of trusting to mercurials nearly exclusively, or after they have been administered without benefit, or in the strumous diathesis, where for the most part they are not well tolerated, I would advocate the use of renal depurants, especially of acetate of potass.

416. Although in these remarks I have especially alluded to the acetate of potass, yet I have merely selected

it as a type of a large class of remedies, many of which equal it in their remedial effects. The citrates and tartrates of potass and soda constitute remedies of probably equal value. Indeed, the utility of the popular "saline draughts" of these salts is in all probability to be explained by their influence as renal depurants. The solution of potass and soda, as well as their carbonates, are most useful remedies of their class, but decidedly of much less value than the acetates and citrates. Two reasons may be given for this, first, they are very likely to become neutralized whilst in the *primæ viæ* by acids, which, like the hydrochloric and phosphoric, are not decomposed whilst passing through the circulation; secondly, the conversion of acetates and citrates into carbonates takes place in the blood, and thus they *in the nascent state, when their chemical tendencies are the highest*, come in contact with those matters which it is important to eliminate from the blood. It is well known that a considerable quantity of liquor potassæ (160) is required to render the urine even neutral, whilst a few grains of an acetate or tartrate will rapidly render it alkaline (162).

417. Having thus explained my reasons for believing in the existence of an important class of remedies, the renal depurants, capable of replacing with advantage in many cases mercurial alteratives, I dare not trespass further, as the very introduction of this chapter demands an apology, as being somewhat foreign to the design of this volume. The only excuse I can offer is the unwillingness that the results of some very tedious and protracted, but I hope not useless, observations should be lost, and the too well grounded belief that I may never be permitted to make them known, as I had once hoped, in another and more extended form.

APPENDIX.

CATALOGUE OF THE URINARY CALCULI CONTAINED IN THE MUSEUM OF GUY'S HOSPITAL.

In the year 1817, when Dr. Marcet published his Essay, the Museum of Guy's Hospital contained but 228* calculi. During the last twenty-seven years, this number has been augmented to 374; all of which have been divided so as to exhibit their internal structure, with the exception of 21. The great majority of the calculi added since Dr. Marcet's publication have been analysed at different periods, as they were placed in the Museum, by Dr. Babington, Dr. Rees, and myself;† and in every instance, the examination has not been limited to the composition of the external crust, but has been particularly directed to the chemical constituents of the ingredients composing each layer. Attention has in each specimen been directed to the composition of the nucleus, in contradistinction to that of the body of the concretion. This is of very great importance; for when once a few solid particles of any substance aggregate and form a mass in the bladder, they very readily induce a crystallization of oxalate of lime, uric acid, or triple phosphate; or a deposition of urate of ammonia, phosphate of lime, or other amorphous ingredient, according to the lesion of function and state of irritability or enervation present. Hence, if ever, by medical treatment, we shall be enabled to prevent the formation of a calculous concretion, or remove one

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* Including 142 removed from one patient.

† Still more recently Mr. Bransby Cooper has continued these investigations, and added largely to the collection of calculi in the Museum.

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already formed, it will, in all probability, be by means directed by the character of the matter which there is a tendency to deposit as a nucleus. On this account I have adopted a classification of the calculi in Guy's Hospital Museum, founded not upon the number of alternating layers, but upon the character and composition of the nuclei. In the following Table, it must be borne in mind, that all the distinct constituents present in each concretion have not been mentioned; those only being inserted which were present in such quantity as to constitute a considerable portion of either body, nucleus, or crust of the concretion. Those ingredients, which existed in mere traces, or in very minute quantities, have been omitted; as they are rather to be regarded as accidental contaminations, than as essential elements of the calculus. No urinary concretion, indeed, ever exists perfectly pure and unmixed; for there are very few in which some traces of uric acid, or phosphates, are not observable: and even if these be absent, the colouring matter of urine or blood prevents the calculus being regarded as perfectly pure.

CALCULI IN GUY'S HOSPITAL MUSEUM,

OF WHICH SECTIONS HAVE BEEN MADE,

ARRANGED ACCORDING TO THE CHEMICAL COMPOSITION OF THE NUCLEI.

Genus I.—Nucleus, Uric Acid, 250.

Species 1. *Calculi nearly entirely composed of Uric Acid or Urates.*

A. Nearly all uric acid		32
Uric acid, nearly pure	18	
Stained with purpurine	2	
Contained urate of lime	2	
" " and ammonia . . .	3	
" urate of soda and lime . . .	2	
" oxalate of lime	2	
" phosphate of lime	1	
" triple phosphate	2	
	32	

B. Body consisting chiefly of urates		170
Contained urate of soda	142*	
" " and lime . . .	22	
" urate of lime	4	
" uric acid in the body . . .	2	
	170	

Species 2. *Bodies differing in composition from Nuclei.*

A. Bodies consisting of oxalate of lime		11
Oxalate of lime and uric acid alternating . . .	2	
Uric acid in the body, with an outer layer of carbonate of lime	1	
Oxalate, chiefly confined to external layers . .	1	
Oxalate of lime in the bodies nearly pure . . .	7	
	11	
B. Bodies consisting chiefly of earthy phosphates . .		24
Bodies composed of fusible calculus . . .	16	
" phosphate of lime . . .	3	
" triple phosphate . . .	5	
	24	
C. Body consisting of carbonate of lime	1	1
D. Body compound		12

Body:	Crust:		
Urate of ammonia . .	Fusible . .	1	
Oxalate of lime . .	Uric acid .	3	
" . .	Fusible .	3	
" . .	Triple . .	1	
" . .	Phosphate of lime .	3	
Fusible . . .	Uric Acid .	1	
		12	

* From the same patient.

Genus II.—Nucleus, Urates of Ammonia or Lime, 19.

Species 1. *Calculi nearly all compound of Urate of Ammonia* . 8

Urate of ammonia, nearly pure	6
Uric acid, in tubercular patches on crust . . .	1
Traces of urate of soda and phosphate of lime . .	1
	8

Species 2. *Bodies differing from Nuclei* 10

Body:	Crust:	
Uric acid and fusible .	As body . . .	2
Urate of ammonia .	Uric acid . . .	1
" " .	Oxalate of lime . .	1
" " .	Phosphate of lime . .	1
" " and oxalate of lime . .	Uric acid with oxalate and phosphate of lime . .	1
Urate of ammonia and fusible . .	As body . . .	1
Urate and phosphate of lime	Ditto . . .	1
Oxalate of lime . .	Fusible . . .	1
Fusible . . .	As body . . .	1
		10

Species 3. *Nucleus Urate of Lime.*

A. Body fusible 1 1

Genus III.—Nucleus, Uric Oxide, 1.

Species 1. *All Uric Oxide** 1

* A portion of the calculus removed by Langenbeck, at Hanover, and analysed by Wöhler and Liebig.

GENUS IV.—NUCLEUS, OXALATE OF LIME, 47.

Species 1. *Calculi nearly all of Oxalate*		19
Uric acid in nucleus	1	
Crust, covered with opaque octahedral crystals	1	
" " transparent	3	
" not covered with crystals	14	
	19	

Species 2. *Bodies differing from Nuclei.*

A. Bodies consisting of uric acid or urates		8
Uric acid, nearly pure	7	
" covered with urate of ammonia	1	
	8	
B. Bodies consisting of phosphates		14
Phosphate of lime	6	
Triple phosphate	5	
Fusible mixture	3	
	14	

C. Body compound			6
Body:	Crust:		
Uric Acid	Fusible	2	
"	Oxalate of lime	1	
Urate of ammonia	Phosphate of lime	1	
1. Uric acid 2. Oxalate of lime 3. Uric acid	Oxalate of lime	1	
Cystine		1	
		6	

Genus V.—Nucleus, Cystine.

Species 1. *All Cystine*		11
Colour, greenish blue	1	
„ dirty greenish grey	9	
„ fawn brown	1	
	11	

Genus VI.—Nucleus, Earthy Phosphates, 22.

Species 1. *All Phosphates of Lime*	2	2
Species 2. *All Triple Phosphates*	1	1
Species 3. *All Fusible Mixed Phosphates*	19	19

Genus VII.—Ingredients of Calculi mixed, with no evidence of arrangement in concentric layers, 3.

A. Uric acid and triple	1
B. „ phosphate of lime	1
C. „ urates of soda and ammonia, with oxalate and phosphate of lime	1
	3

ABSTRACT VIEW OF THE NUCLEI.

Nuclei, consisting of uric acid or urates	269
„ „ oxide	1
„ „ cystine	11
„ „ oxalate of lime	47
„ „ phosphates	22
	350
Mixed calculi	3
	353
Calculi undivided	21
	374

I have not included in the above Tables the fibrinous calculus of Dr. Marcet, in consequence of its differing so totally from other concretions; as it must be regarded as a portion of dried inspissated albuminous matter exuded from an irritated kidney, rather than as a calculus produced under circumstances at all analogous to those of other concretions. Several specimens exist in the Museum, of the pelves of kidneys and ureters being obstructed by clots of fibrin; but none of them present the hard, concrete condition of the calculus described by Dr. Marcet. I am not aware of this variety having been mentioned by any other except Brugnatelli, who, in his Litologia Umana, describes some calculi as consisting of *crystallized* albumen (di materia albuminosa cristallizata di colore d'ambra): they were passed by one individual, and each was about the size of a nut. These pseudo-calculi were supposed to consist of dried coagulated albumen, which not unfrequently presents considerable lustre, and a vitreous fracture, although scarcely sufficient to justify its being regarded as crystallized. I confess I have a strong suspicion that the calculi described by Brugnatelli really consisted of cystine.

Among the other ingredients existing in calculi in very minute quantities, and not enumerated in the Table, are hydrochlorate of ammonia, oxide of iron, and carbonate of lime. The former has been described by Dr. Yellowly as a frequent ingredient, generally, however, existing in mere traces of calculi; the second was discovered by Professor Wurtzer, and is often present in uric acid calculi; and the third is frequently present in phosphatic and oxalic concretions. None of these ingredients are so generally present as to merit their being regarded as presenting much interest in a pathological sense.

Calculi present the greatest possible variety in appearance; generally, however, having more or less of an ovoid figure. Of those in Guy's Museum, the urate of ammonia and uric acid concretions are the most regular, nearly all being ovoid or circular,[a] a few only reniform;[b] this species never presenting any very prominent processes or projections, unless fresh centres of deposition occur on their surfaces, as when crystals of uric acid are deposited on an ovoid urate of ammonia concretion.[c] The cystic oxide concretions vary considerably in outline; when large, being generally oval and smooth;[d] and when smaller, often presenting projections from their surfaces, as if they were made up of crystals radiating from a common centre;[e] sometimes being moulded to the figure of the organ which secreted it, as shown

Reference to Calculi in the Museum.

[a] No. 2113. [b] No. 2119. [c] No. 2125.
[d] No. 2143 [e] No. 2145.

in the curious ear-drop-like concretion.[f] The oxalate of lime is generally most irregular, as far as the surface is concerned, although its outline is generally tolerably defined, either bearing a close approximation to an elliptic or even a rectangular figure. The most contorted and irregularly figured calculus is the triple or fusible, it being often a complete cast of the pelvis and calyces of the kidney;[g] occasionally, however, it is almost regularly oval, and sometimes circular;[h] this variation, in all probability, depending upon the position occupied by the calculus, and upon whether it had been retained in the kidney, or passed down the ureter before it had become of any considerable size. The mixed calculi, or those not presenting any regular concentric arrangement or a distinct nucleus, are often moulded to the kidney.[i] The phosphate of lime calculus is generally smooth externally, and conchoidal in fracture, sometimes appearing as if made up of several cohering portions.[k] The triple phosphate[l] and fusible mixture[m] are not unfrequently found deposited on one side of a previously formed calculus, as if one surface only had been exposed to the urine containing the earthy salt in solution, which is generally found under the form of elegant white vegetations.

The nucleus is usually found in the geometric centre of the calculus, or nearly so; sometimes, however, being remarkably eccentric, as in some reniform concretions;[n] and in a few, several distinct nuclei or centres of deposition are met with.[o] In some rare instances, the concretion which forms the nucleus is found loose within the body of the entire calculus; a circumstance in all probability arising from a layer of blood or mucus having concreted around the nucleus, and on which the matter forming the body of the calculus became deposited.[p] In this case, on the whole becoming dry, the mucus or blood would be diminished to a very thin layer, and the calculus would appear to contain loose matter in it. In a few instances, calculi appear to possess no nucleus, the centre being occupied by a cavity, full of stalactitic or mammillated projections, giving the idea of the external layer having been first formed, and the mammillated portions subsequently formed in the interior. This state occurs only, so far as I have seen, in uric acid calculi.[q] In one specimen in the collection the central cavity is lined with fine crystals of triple phosphate, resembling the crystals of quartz so often found lining cavities in flints.[r] Brugnatelli describes one of a similar kind.

Sometimes calculi present very remarkable appearances, as if they had been divided into segments. This, in some cases, can be explained by the attrition

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[f] No. 2145.[36] [g] No. 2163. [h] No. 2161. [i] No. 2136.
[k] No. 2148. [l] No. 2198. [m] No. 2154.[3] [n] No. 2119.
[o] No. 2158. [p] No. 2133. [q] No. 2113. [r] No. 2154.

of calculi[a] against each other, where several exist at once. In some, they actually appear as if they had been divided by a fine-cutting instrument; and in one, in the Museum, the apparently divided portions seem as if they had again become cemented and framed in by a subsequent deposit.[b]

An American physician, Dr. Peter, has submitted to a very elaborate examination the calculi contained in the Museum of the medical department of the Transylvania University, and the results of his researches offered a very interesting comparison with the above details of my own.

ABSTRACT VIEW OF THE COMPOSITION OF CALCULI IN TRANSYLVANIA UNIVERSITY MUSEUM.

Nuclei consisting of uric acid nearly pure	32
" " urate of ammonia	26
" " cystine	2
" " oxalate of lime	7
" " phosphates	7
" " foreign substances	4
	78
The bodies were composed of uric acid chiefly in	34
" " urate of ammonia	2
" " cystine	2
" " oxalate of lime	16
" " mixed phosphates	66
" " triple phosphates	4
	124
The cortical portion was composed of uric acid in	34
" " " urate of ammonia with phosphates	2
" " " cystine	2
" " " oxalate of lime	9
" " " mixed phosphates	37
" " " triple phosphates	2
	86

[a] No. 2218.[63]   [b] No. 2136.[50]

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ALPHABETICAL INDEX.

ERRATUM.

Page 94, third line from bottom—"As these views," to "their fallacy"—ought to have been in a note referring to the passage bracketed.

J. E. Adlard, Printer, Bartholomew Close, London.